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SCHOOL LESSONS
IN
PLANT AND ANIMAL LIFE

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SCHOOL LESSONS
IN
"PLANT AND ANIMAL LIFE"

BY
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PREFACE.

THE lessons submitted in the following work have mostly undergone the test of actual experience in that they have formed a material part of the instruction submitted to various Teachers' classes. Particulars regarding the general plan and aim of the book are given in the Introduction (pages xiii-xvi).

As regards the illustrations the author is indebted to various sources. In particular he desires to acknowledge the assistance of Mr. Alexander Reid for drawing the figures of gnats and fishes, of Mr. George Paterson Duffus for photographs (Figs. 30, 31, 41, 75, 140, 144, 145, 173, 180), and of Mr. Holmes, Photographer, Rochester, for the remainder of the photographs. All of these gentlemen have supplied excellent productions which have materially enhanced the value of the work.

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INTRODUCTION.

How to Use this Book.

The aim of this book is to help teachers of nature study. It has been written primarily for the teacher who has no previous technical knowledge of plant or animal structure and life, but is willing to learn in the only way by which real efficiency can be reached and maintained. It provides a full course of work seasonally arranged, which could be distributed over two years, supplying the actual matter of over eighty lessons upon subjects of universal interest in plant and animal life. The book also contains various accessory aids such as hints on sources of materials, outline courses in particular groups, and guidance as to books likely to be of value in special subjects.

Under each heading will be found in most instances more subject-matter than it is possible to deal with in a single school lesson, and in places a certain amount of matter beyond the capacity of the average senior pupil in a primary school. This is of course absolutely necessary owing to the fact that the *aim of the book is the instruction of the teacher* in matter as much as in method. If teachers are to profit by the use of the book, they must *prepare the lesson by working through the whole of it* as given in the text, and for this purpose the treatment is not too full. It must be left to the teacher's judgment just what and how much the pupils are to be guided to see and to reflect upon.

The lessons are given as if addressed directly to the pupils, but it is not intended that the form of presentation should be even approximately reproduced. The object of printing the lessons in this form is that the teacher should be guided as to methods of presentation which the author considers likely to be most useful, and should learn the intellectual outlook on nature which it should be his ideal to convey and the *temper* in which these studies should be carried out; these things he can learn only by example—they are very difficult to explain. The writer is fully conscious that he has failed to fulfil his own ideals; but if he has been able to suggest even indirectly what the ideals are, better teaching he hopes will result.

It will be noted that in the presentation of the lessons there is no slavish adherence to any particular academic "method," a procedure which may provoke the criticism of those who pay more attention to methods than to results. In nature study, however, the stereotyped method is fatal—one can dogmatise to that extent at least.

The range of lesson subjects is wide, and the teacher is free to choose those materials which are most likely in his opinion to quicken the intellect and stir the imagination of the pupil. While this is so, each of the leading subjects, *e.g.* flowers, trees, birds, mammals, insects, has been dealt with throughout the book in such a way as to provide a coherent scheme of instruction which school children may be expected to follow with intelligent interest. It is hoped that this arrangement, together with the various accessory aids to be found in the work, will enable the teacher to frame such revision lessons as will render the instruction systematic and constructive *as far as it goes* whilst maintaining unimpaired the endeavour to develop an intelligent and interested observational attitude towards Nature.

As regards the scope of the individual studies it need not be explained that the author has not aimed at a complete survey of any particular animal or plant, but rather at the selection of the salient points of interest in each case. For example, in the case of flowering plants, the flower, and in most instances the flower alone, has formed the object of study. This is because the primary aim of the teacher should not be to instruct in systematic botany or zoology, but by the exercise of observation and kindred means to increase knowledge and appreciation of objects which are already things of real interest in the child's environment.

For the same reason lessons are included dealing with subjects which cannot be demonstrated in the classroom with living materials, *e.g.* birds and beasts. The idea that indoor work in nature study must be confined to the examination of "specimens" limits the outlook unduly.

Laboratory studies are doubtless disciplinary and it is also true they may be made subservient to the development of observation out of doors. They fail largely if they do not do so. But such studies remain inadequate so long as matters of supreme interest in nature, *e.g.* the activities of the birds of the air and the beasts of the field and of many other forms of life which abound in the child's environment but cannot be introduced into the classroom—are excluded from consideration within the school (see p. 101).

At the same time, it is fully realised that the planning of such lessons requires particular care, and here the general aims of our work must be constantly kept in view. Particular rules cannot be laid down. It may be suggested, however, that an endeavour should always be made to develop the lesson on the basis of the pupils' present knowledge and of enquiry into the significance of things previously seen, and also to suggest future observation out of doors.

It is believed that, *given the materials*, the teacher who is without previous training in biological subjects will be able, with the help of this book, to instruct himself in the first instance and subsequently his pupils. In the case of flowers, for example, there are very few dealt with in the lessons which are not likely to be known at sight by the teacher, and none which are uncommon. But in those cases where a teacher has difficulty in finding the correct plant, it would be advisable for him to procure specimens for study from some Plant-supply Association, such as those named on page xvi. A similar course should be adopted with regard to leaves and twigs of trees which are not known, or parts of particular plants, *e.g.* rhizomes, tubers, etc. Having obtained these specimens, the teacher will be able to identify similar materials in his own locality, after which progress in school work should be fairly easy.

In identification of animals no difficulties are likely to occur, unless possibly with regard to some of the smaller fresh-water forms. Reference to the text, and to some of the works quoted below, should be of material help.

Lastly, it may be mentioned that the lessons are to be regarded as part of a scheme—as is indeed implied in the book—which includes regular outdoor observations systematically considered and recorded in some form of Nature Calendar. The author has already dealt fully with this aspect of the work in *Aims and Methods of Nature Study.*

Books for the Teacher, Class Materials, etc.

The following list of books is given as likely to prove useful to the teacher who desires to consult works of reference upon the subject of animal and plant life. Some at least, if the full number is not attainable, might form a nature study collection in a school library. Whilst books are necessary and helpful, the teacher should never allow these to take the place of observation of facts at first hand, and it is to these alone that the appeal must be made in the presence of the pupils.

Books dealing with Plants.

Elementary Botany (Percy Groom). Bell and Sons.
Text-Book of Botany (Lowson). Univ. Tutorial Press,
Life Histories of Common Plants (Cavers). Univ. Tutorial Press.
Plant Biology (Cavers). Univ. Tutorial Press.
Text-Book of Botany (Strasburger). Macmillan.
Agricultural Botany (Percival). Duckworth.
Flowers of the Field (Johns). S.P.C.K.

Books dealing with Animals.

British Museum Guide to the British Vertebrates. Obtainable at the Museum, South Kensington, S.W.
British Museum Guide to the British Birds, General Series. Obtainable at the Museum, South Kensington, S.W.
British Museum Guide to the British Birds, Nesting Series. Obtainable at the Museum, South Kensington, S.W.
Britain's Birds and their Nests (A. Landsborough Thomson). Illustrated by Geo. Rankine. Chambers.
Insects, their Structure and Life (Carpenter). Dent.
Butterflies of the British Isles (South). Warne and Co.

Moths of the British Isles (South). Warne and Co.

Natural History of Aquatic Insects (Miall). Macmillan.

Natural History of Some Common Animals (Latter). Deals with Earthworms, Dragon Flies, Snails, Frogs, etc. Camb. Univ. Press.

Life in Ponds and Streams (Furneaux). Longmans, Green and Co.

The Animal World (Gamble). Williams and Norgate.

General Biology, etc.

The Sea Shore (Furneaux). Longmans, Green and Co.

Aims and Methods of Nature Study (Rennie). Univ. Tutorial Press.

Leaflets of the Ministry of Agriculture and Fisheries.

Preservation of Materials.

Glass Jars, etc.

Teachers should write for Catalogues to Messrs. Flatters and Garnett, Deansgate, Manchester.

Preserving Fluids.

Small animals, *e.g.* pond materials, rare creatures, and other material generally which the teacher wishes preserved, may be kept in Formalin. Dilute the commercial product with water to ten times its bulk. Objects containing calcareous matter must be kept in alcohol, *e.g.* 70 per cent. strength.

Supply of Materials.

Plant Specimens.

The Director, Botanical Supply Agency, Rhydyfelin, Aberystwyth.

Animal Specimens

Edward Gerrard and Sons, 61 College Place, Camden Town, London, N.W. 1.

Marine Specimens.

The Director, Marine Biological Laboratory, Citadel Hill, Plymouth.

PLANT AND ANIMAL LIFE.

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CHAPTER I.

PLANT STUDIES IN SPRING.

LESSON I.

TWO COMMON SPRING FLOWERS.

The Lesser Celandine (*Ranunculus ficaria*).

[This plant flowers as early as the month of March. It abounds in damp shady places by the banks of streams, but may sometimes be found in open pastures. Pupils should be told where in their own neighbourhood they may see it growing. They may be asked in suitable instances to bring their own specimens to school for study. They must dig up an entire plant. Some complete plants may be kept indoors in a vessel in a little water; the development of "bulbils" will probably follow, and these may then be demonstrated to the pupils. For the purposes of the lesson each pupil or pair of pupils should have a specimen plant.]

This flower is specially interesting to us because it is one of the first to appear in spring. It early decks the grassy banks of streams before any other flowers have appeared there. Although it is common, few think of it as common-place. One reason for this is that most people are glad to see it because they look upon it as a sign of spring's appearing. You know that Wordsworth speaks of it as "telling tales about the sun," before much warmth can be felt in its rays.

Will you, therefore, write down in your notes as the first fact of interest about the lesser celandine, that its flowering marks the coming of spring.

Then, do you not think it is an attractive looking flower? It certainly is, in its natural home—fresh, glossy and star-like, glistening amongst the grass in a shady hollow. If any of you have not seen it growing, you should endeavour to do so.

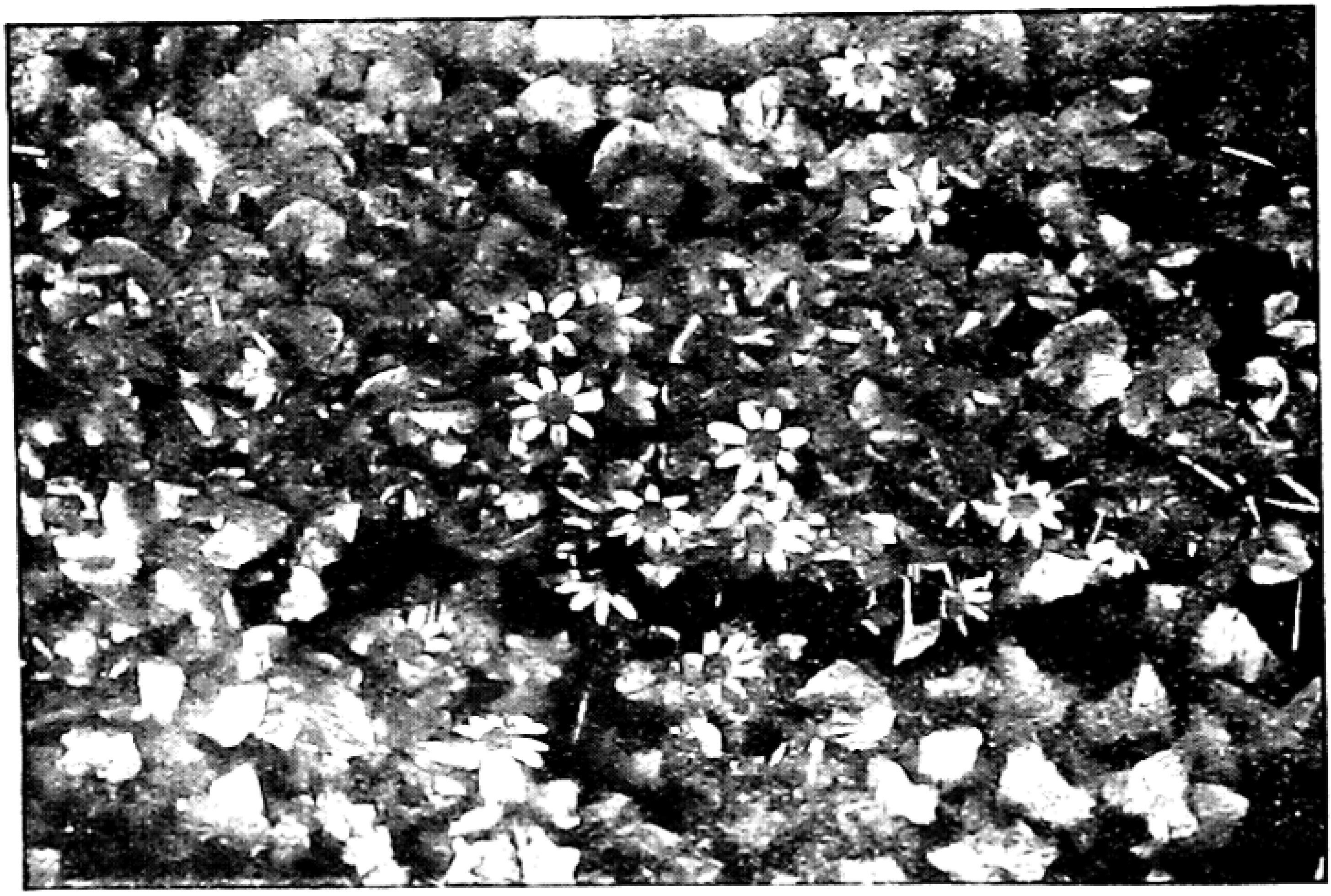

Fig. 1.—The Lesser Celandine.

A Buttercup compared.—What common flower does it resemble? A **buttercup.** Yes. It is, in fact, a buttercup; there are a good many different kinds **(species)** of this type **(genus)** of flower. Look closely at the one in your hand. Can you say in what respect it differs from an ordinary field or wayside buttercup? Notice, first the petals. These, you observe, are **narrow.** Has a wayside buttercup got narrow petals? No; in it the petals are broader. How many of these do you find in the lesser celandine flower? Mostly seven or eight. You discover that the **number of petals varies.** Remove a petal and draw it. Do you remember the number in a wayside buttercup (*Ranunculus repens*)? Five in this case. Look next at the sepals in your flower. How many? **Three sepals** in the lesser celandine. Can you tell how many in the other case? Five. These are the parts you are most likely to remember about, and they are the parts in which the two kinds of buttercup differ most. The remaining parts of the flower are very similar in the two cases.

As the season progresses you should look out for the appearing of different kinds of buttercups, of which there are several (pp. 161, 162).

Carpels and Stamens.—Look at the heart of the flower, and observe the cluster of green bodies situated there. You may detach some of them and examine them upon a sheet of paper. Notice their shape. Draw one. These are the **carpels.** Each contains an egg-body **(ovule)**, which gives rise under suitable conditions to a seed. You observe around the carpels, numerous **stamens** with their yellow **anthers** containing **pollen,** for which insects visit the flowers and which the insects frequently scatter upon the tops **(stigmas)** of the carpels. Draw a stamen.

You must do this work carefully, noting and remembering what the parts of each flower you examine are like, so that you may become familiar with resemblances and differences amongst them. An excellent plan is to draw each part you examine and to write down the numbers of each part present in the flower.

Have you noticed that this flower closes in the dark and in dull weather? Do you know what the opening of the flower with its display of colour really means? This is meant to attract insects. These come, some for pollen and others for nectar. You have just seen where the pollen may be found. From whence do the insects obtain the nectar? Look at your drawing of the petal. If this has been made correctly it will show a little scale-like structure forming a small pocket-like recess near the base. This is a **nectary,** a place where a sweet honey-like substance is formed. You may find it also upon the petal of a common buttercup. If you have missed this, look once more

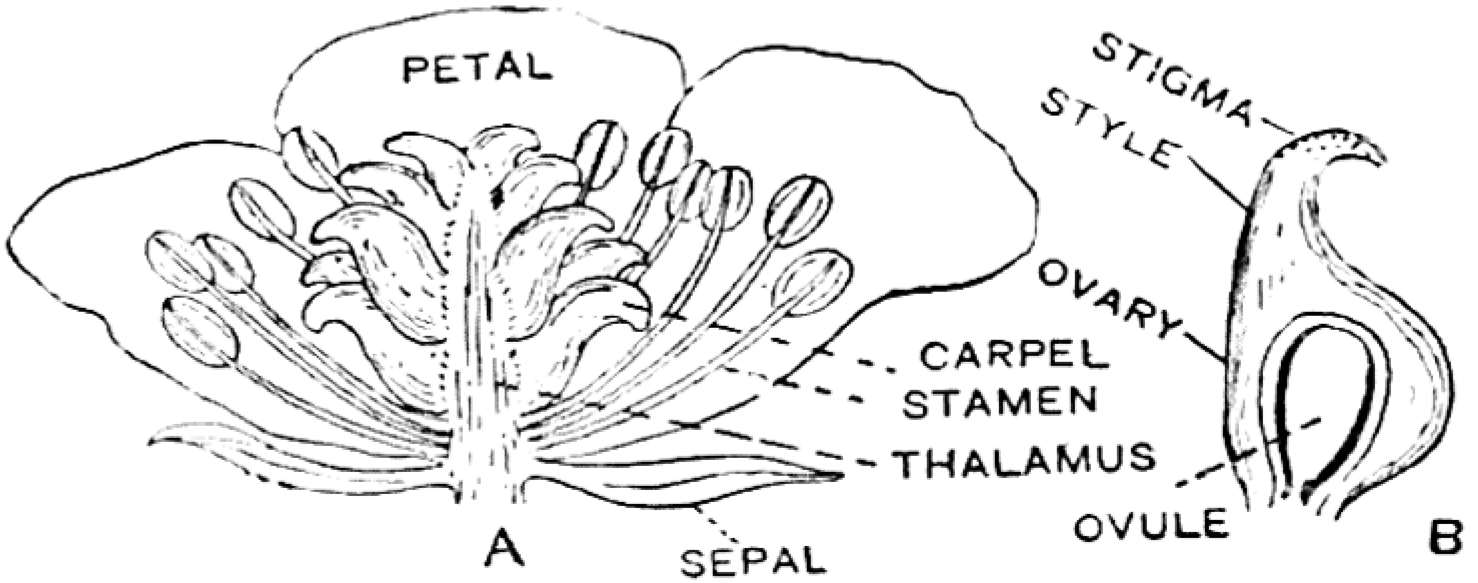

Fig. 2.—A, Half-Flower of Buttercup; B, Section of a Single Carpel.

at a petal and find it. But flying insects, especially at this time of the year, are not very numerous in dull weather or after dusk, also the pollen is best kept dry, and so the flower closes. What is the colour of the outer side of the petals? Green. Thus the flowers are rendered inconspicuous when closed and very noticeable when they are open.

While insects are gathering pollen or nectar they usually render some service to the flower. Can you say what this is? They may bring pollen attached to their bodies from one flower and rub it upon the stigmas of another, or they may scatter pollen upon the stigmas within the same flower. These things are for the making of seed. (Frequently in the case of this flower, insect visits are rare, and the flowers fail to produce seed. The plant depends chiefly upon the bulbils mentioned below for dispersal and the production of new plants.)

The Leaf.—What kind of leaf has the lesser celandine? Draw one, noting carefully the appearance of the stalk, the blade, its shape, and the kind of surface it has both above and below.

The Root.—Examine the roots. What do you find? Thread-like, and also rounded or oval-shaped bodies, pale in colour. Cut one of these last. Note the whitish appearance within. They remind us of potatoes, but are much smaller. You might try to think what the nature of this white substance is likely to be, and what use it will be to the plant. There is a great deal of **starch** in these thickened bodies. They are called **tubers,** and they are formed from the roots by being filled up with a store of food. This food is to build up the body of a plant the following year, and one of the reasons why a celandine appears so early in the year is because it has a store of food by it all the winter ready to be used when spring comes.

Draw the roots, showing their tubers.

If you look at this plant later on in the season when the flowers have gone, you may find in the angles of the branches little bodies resembling these tubers. These bodies, called **bulbils,** are also full of a store of food, and they fall off the plant and getting into the ground start a plant just as a seed can do. Plants kept indoors in a little water will be found to develop the bulbils in course of time.

You should now write down the different ways in which new celandine plants may appear.

(1) They may grow from seed. This is rare.

(2) They may grow from root tubers left in the ground.

(3) They may grow from bulbils formed on the parts above ground.

Revise, by examination of the flowers themselves, and with the help of the diagram (Fig. 2) the following parts:—

Sepals, petals, stamens (including the parts filament and anther), carpels (including ovary, style, stigma).

The Wood Anemone (*Anemone nemorosa*).

In the wood anemone we have another familiar plant, whose appearance is always a welcome and a pleasing sight. Flowering in the cold winds of March, it speaks the same message as the lesser celandine—spring is coming. It unfolds its graceful rays in the yet feeble and scanty sunlight, decking the woodlands and waysides with its fresh and delicate beauty. It sways upon its slender stalk, spreading its delicately tinted sepals in answer to the rough touch of the wind. Have you noticed this? It is because it opens when the wind is blowing that it is called the wind flower or anemone.

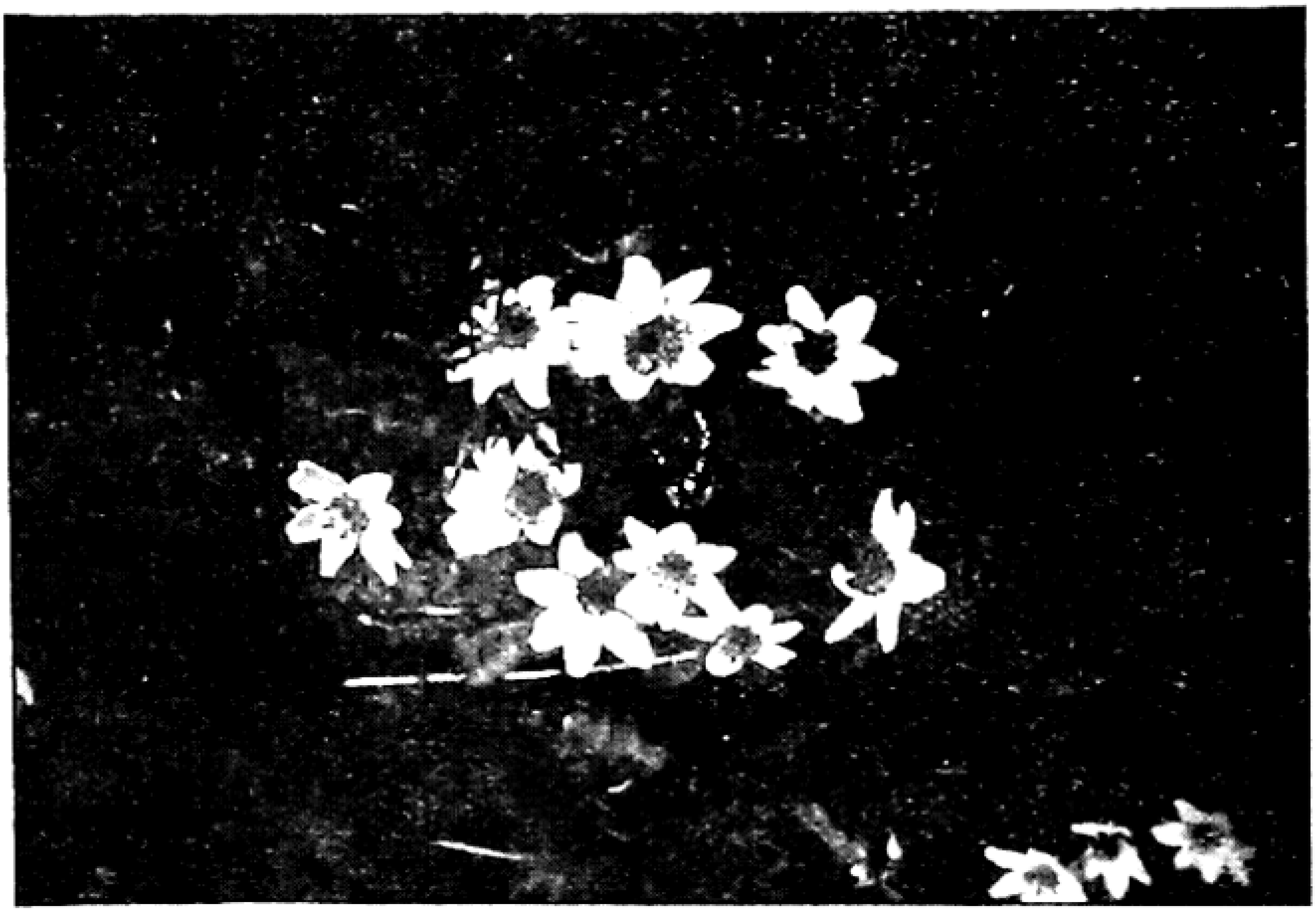

Fig. 3.—The Wood Anemone.

Notice, too, how gracefully it droops with half-closed sepals, showing the tinted outer side. You must look at the anemones as they grow, so fresh and delicate on some shady bank, so that you may feel the pleasure of their charm (Fig. 3). This is the first part of our lesson—to learn to appreciate this fragile, graceful flower. It is not a difficult task.

Parts of the Flower.—You are already familiar with the parts that are usually present in a flower—sepals, petals, stamens, and carpels. We shall look for these here.

In the centre we can see the seed vessels (carpels) quite clearly. There is a cluster of them—too many for us to count—close together, but quite separate from each other. Around them are the stamens, also numerous. In these two particulars the anemone and the lesser celandine are similar.

Now you notice that there is only one other part of the flower still remaining, viz. the ring of white tinted parts. There are in some anemones as few as five of these, and more in others, up to as many as nine sometimes. What are these? We are all inclined to call these petals. They are like them and **do the same work as petals.** That is, they are the attracting part of the flower. They **also do the work of sepals,** protecting the more important parts in the centre. Botanists tell us that these are really the **sepals which have become like petals in appearance,** and that the petals are really absent. You will understand this better when you are older and have thought a little about the history of flowers and how they have come to be as they are.

Insect Visits.—Have you ever seen any insects visiting this flower? When you do so you must be sure to look at them and watch what they are doing and getting. This flower does not secrete honey.

Flower-droop.—What is the meaning of the droop in this flower and in many others? Flowers which hang their heads and close at night or in dull weather in this way avoid the risk of the pollen getting wet. Compare the behaviour of the lesser celandine.

Bracts.—Notice that there are always three very much divided leaves (**bracts**) a little way below the flower.

The flower stalk above these leaves is more slender than below, and in this part the droop occurs which turns the inner side downwards away from the rain. Notice that the leaves upon the flower region of plants are termed bracts.

Underground Stem.—Down below the surface of the ground you will find growing horizontally a slender brownish stem, showing scars where former branches rising above ground had come off, and at the tip of which forward growth is taking place. Within this underground stem (**rhizome**) food is stored throughout the year. This plant is able to unfold its flowers early the following spring. You thus see that the same plant goes on growing year after year. A plant which does this is called a **perennial** plant. Whilst that is so, the flowers are each year producing seed which are scattered by the wind and other agents, and these start entirely new plants in fresh places.

Write down some important things to remember about these two flowers, *e.g.*

How they are able to flower early in the year.

How they behave in dull or in wet weather.

What the nature of the white floral parts of the anemone is.

The different ways in which these plants continue year after year.

A lesson upon the marsh marigold or king cup (*Caltha palustris*), which may be found at the same time, may be given along with or in place of either of the foregoing. In this flower also the yellow conspicuous part consists of sepals. There are honey glands at the base of the carpels. Note the adaptations in stems and leaves to the marshy habitat.

LESSON II.

DAFFODILS (*Narcissus pseudonarcissus*).

[Give to each pair of pupils a specimen plant.]

Most of us know this flower, not as a wild flower, but as one cultivated in gardens or in private grounds, or nurseries. The daffodil is a specially attractive early spring flower. Here is its first charm for us.

> ". . . . daffodils,
> Which come before the Swallow dares,
> And take the winds of March with beauty."

The daffodil is a wild flower, occurring in various parts throughout the British Isles in damp woods.

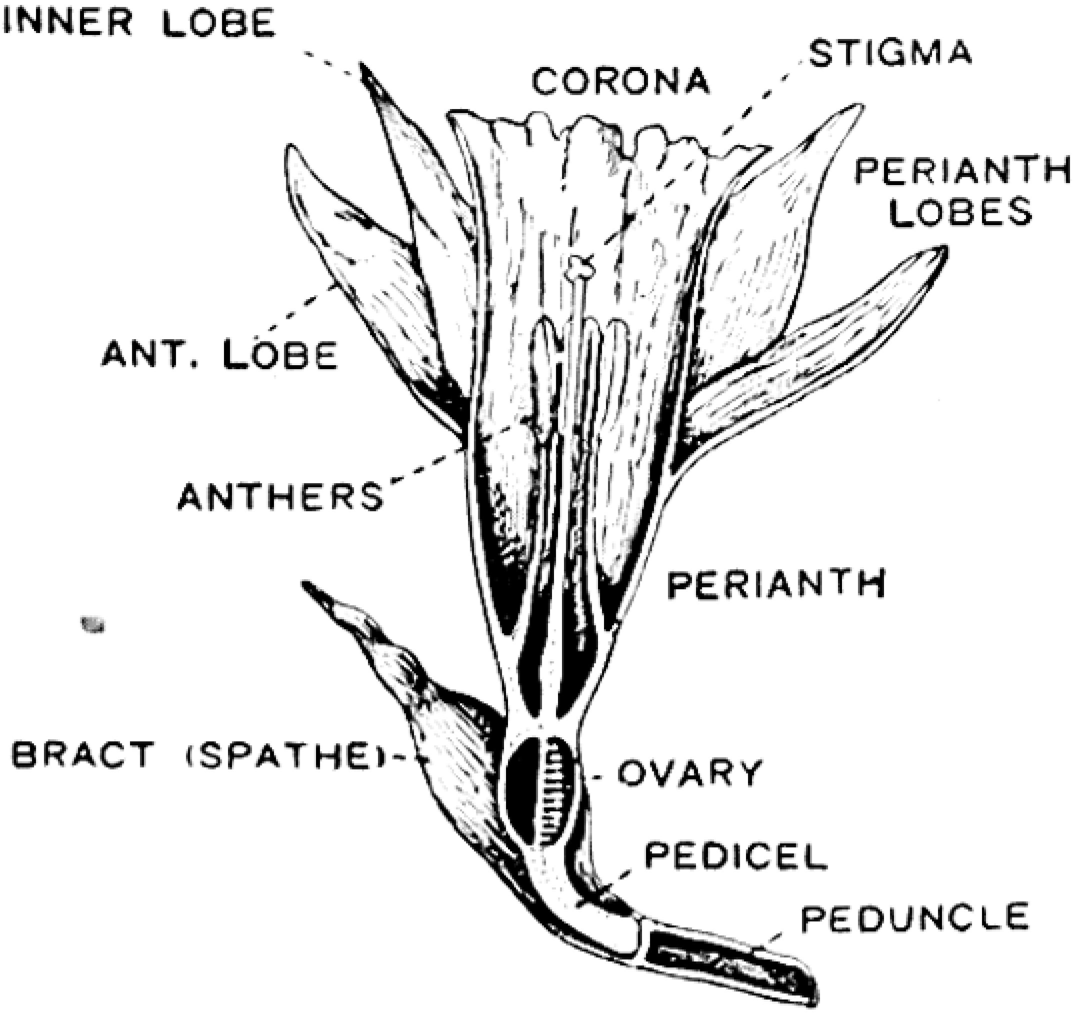

Fig. 4.—Half-Flower of Daffodil.

Let us try to name the attractions which daffodils have for us. We have already noted that they come when flowers are scarce. They are large flowers, beautiful both in form and in colour, with an attractive smell. Do you think you could describe the smell of daffodils? Do they not suggest "freshness?" They have an agreeable refreshing odour, which is very pleasant to our nostrils.

The Parts of the Flower.—Let us look at the shape of this flower (Fig. 4). There are six delicate parts like petals, forming a star-like form. We do not see behind these any green parts such as are common in a great many flowers (sepals). In flowers of this kind these six parts are named collectively the **perianth.**

From the centre of the perianth there rises up a wide trumpet-like tube. In the inside of this tube you can see projecting the six stamens and the long pistil with its three flattened lobes at the tip (**stigma**).

This is not a common flower form. What is unusual about it? There is a long wide tube around the centre. This is an extra part, and you see, do you not, that it adds greatly to the beauty of the flower? That it serves to make the flower attractive, not only to us but to insects also, is quite certain. This tube is known as a **corona.** Look at it closely, and note its deep colour contrasting agreeably with the paler perianth, and also its soft wrinkled surface which heightens the beauty of the flower.

Attitude of Flower.—How do the flowers of the daffodils stand upon their stalks? At first they are erect, but when they open they are then placed horizontally.

I am sure you can tell what is the advantage in this? If you look inside the corona you will see that the anthers have already opened and that golden pollen is being shed. The bending down of the flower is useful in sheltering the pollen from rain. We must remember, too, that there is greater risk from the weather at the time the daffodil flowers than in summer. The short stalk turns the flower to the sunlight.

Duration of a Flower.—How long does a daffodil remain unfaded? If you have an opportunity of watching growing flowers you should try to find out exactly. You will find it is a good long time, viz. about three weeks. Can you suggest any advantage in the flower lasting so long? Of course we are very pleased to have these flowers lasting, but they do not exist in the first instance for our pleasure. I think they last all this time in order to give insects an opportunity to visit them, because insects are not very common at the time the daffodils are in flower; in some parts of our country they are very few indeed, so that the daffodils sometimes do not receive any insect visits. When that is so, the chances of their forming seed are rather small.

Nectaries.—If you open a corona tube you are quite likely to find away down at the base that a small quantity of liquid has collected. This is nectar which is formed in the flower. There are three nectaries the entrances to which are placed between the anther filaments. Various kinds of insects may be found within the daffodil. It is an open flower in which there are no special arrangements for excluding undesirable insects, although the corona probably makes it difficult for creeping insects to enter. **Flies** and **small bees** visit the daffodil, as well as **humble bees.** These last are the most useful, because they are able to cause cross pollination. What this is will be explained later (p. 16).

Summary of Flower Parts.—When you have examined the flower carefully, you should make a drawing of it. As you do this, notice how its parts are grouped in threes. There are two sets of three in the perianth, two groups of stamens, three in each, and if you like to cut through the swollen part in the centre (the ovary) you will find it is not single but is made up of three parts (carpels) joined together. You recognise this by the way the ovules are arranged within it.

There are other things to notice in this plant and to ask questions about. Here are some of them. What is the use of the scale-like part at the top of the flowering stalk? Why is this stalk hollow, and what is the advantage in its being pliant? Notice its keeled edges. In what way are these helpful? Note also the twist upon the flower stalk.

Notice the shape of the leaves, their blunt tips, parallel veins, and the bloom upon the surface.

Below the ground, what do we find? A bulb and roots.

Do you know what a bulb really is? What is the advantage to the daffodil in having a bulb? Remember the difficulty some daffodils have in making seed.

The Poet's Narcissus (*Narcissus poeticus*).—This is a plant to compare with the daffodil. Notice the colour—pure white. The number of parts in the perianth is the same. Notice the corona. Here it is quite shallow, greenish yellow in colour, with a crinkled bright red margin, leaving a very narrow opening in the centre.

Stamens and pistil crowd the entrance. Note their exact arrangement.

You can see here that self-pollination is more likely to take place. (What is self-pollination?) The anthers and stigma are ripe about the same time; they lie quite near each other. This flower is suited for visits from **moths,** which have a long proboscis.

The smell is richer and stronger than that of the daffodil, suggestive of pinks.

Nectar is also abundant.

Trace the plant below the ground. What do you find? What is the value of a bulb to a plant?

Draw a narcissus plant.

Supplementary or alternative lessons on similar lines may be given upon the snowflake (*Leucojum aestivum*), and jonquil (*Narcissus jonquilla*). For lesson on snowdrop (*Galanthus nivalis*) see Winter Studies.

LESSON III.

THE WALLFLOWER. (*Cheiranthus cheiri.*)

[*Requisites:* A bunch of wallflowers—yellow and brown. Let each pupil have a flower.]

Attractions.—This is one of the most welcome of the flowers of spring. It is not amongst the earliest, nor one of the prettiest—at least it does not strike us so at first—but it has a charm for us all its own. It has an attraction which few of our early flowers have. Need I ask you to say what this is? **Its scent,** of course. Is it not pleasant? You know, too, how lavish the wallflower is with this, its special charm; how it fills a room so that we feel it even before we notice the presence of the flower itself. It is worth noticing how few of the early flowers of the year are scented. Snowdrop, crocus, and tulip all have their attractions of form or colour, but they cannot delight us in the same way as the wallflower does.

We enjoy the odour of this favourite, but at the same time we do not overlook its other attractions. Has it not also great beauty of colour? At the top of its strong and pliant branches those rich brown or golden clusters of flowers to which the scent is due are very pleasing to look on.

Some General Points.—The wallflower, nevertheless, is best examined closely. Can you say how it is that its appearance pleases us better after we have looked at it closely than after merely a general view?

On a single flower stalk there are a good many individual flowers. Are they all at the same stage? No, some are unopened buds, some opening, some are fully opened, and some are fading. Notice that this order is the order upon the flower stalk beginning at the top, the oldest flowers are lowest down and the youngest nearest to the point. In the fact that flowers of different ages are noticeably clustered together, and especially when fading flowers are present, I think we have the reason why the plant as a whole sometimes does not delight the eye as we would wish.

What is the **colour** of the wallflower? There are two familiar kinds of this flower, the yellow and the brown. There are also various shades of these; a rich orange or a deep glowing reddish brown are two extremes of colour which are both very attractive.

Most of us know the wallflower as a garden plant. But it sometimes grows wild—usually **upon old walls,** and to this cause it owes its name. The **wild form is yellow;** this is a native of the south and centre of Europe.

The Details of the Flower.—Let us now look at a single flower. We shall select one whose petals are spread, but which as yet are held firmly in their place by the tube of sepals behind. You must look and be sure you know the parts just named. The flower at this stage is at its best. The closer we look, and especially if we use a good magnifier, the greater our pleasure.

The Colours.—I must tell you **how this colour is produced.** Within the petals, just below both surfaces, are many small round bodies containing a yellow colouring substance (**chromoplasts**). The same kind of bodies occurs on leaves, but in them the colouring substance is green (**chlorophyll**), and apart from this there is not any very important difference between the structure of a leaf and a petal.

In the brown wallflower there is a **purple sap,** chiefly in the lower side of the petal in which these yellow bodies float. And it is the mingling of these two colours that gives the beautiful ruddy brown we are looking at. You must examine a few petals of brown wallflower and you will see the purple on the underside near the commencement of the narrow part, termed **the limb,** and around the border of the broad part—**the claw**; upon the upper side you may see streaks of the yellow, where the purple sap is rather thin.

Surface of the Petals.—There is another thing which heightens the colour effect. The upper surface of the petals is **soft and velvety,** giving a delicate shading effect, suggesting richness of colour. You may find it difficult to understand this, but I am sure you will agree that the velvety appearance makes the flower prettier in your eyes. The velvety effect is best seen in the brown wallflower.

Arrangement of the Petals.—Notice the arrangement of the petals. If you are looking at a flower at the best stage—that is before the petals have begun to shift from their places—you will see how neatly they lie together. There are four of them, and each lies with one edge of the claw nearly half overlapping its neighbour. Later these parts become freer and then they lie more in the **form of a cross.** The wallflower belongs to the order of plants termed **Cruciferae**—cross-bearing—because of this peculiarity.

Stamens and Stigma.—In the "eye" of the flower you can see the tops of the stamens. You must observe that there are **six** of these and that **two of these are shorter than the rest.** In the centre of the group of stamens notice also the **stigma,** that is the part on to which pollen has to fall if seed is to be produced.

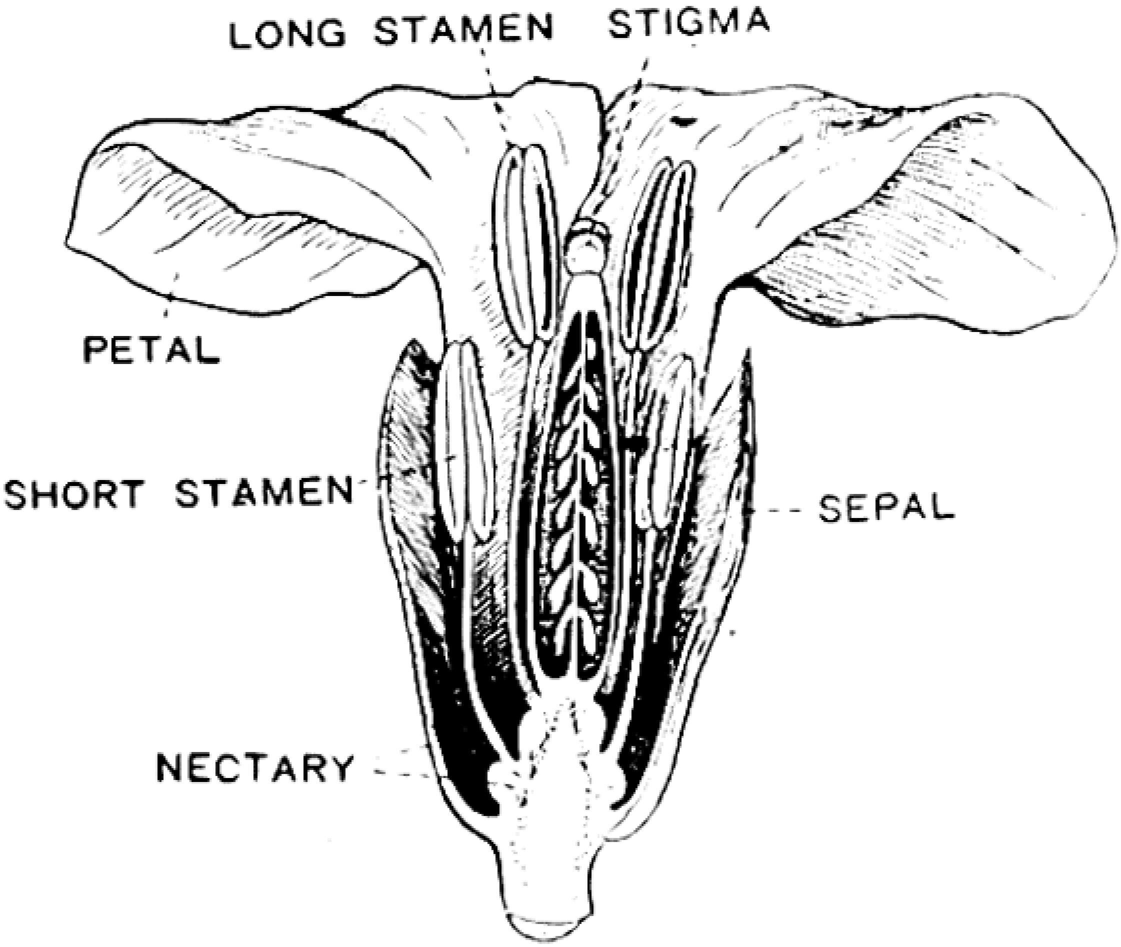

Fig. 5.—Vertical Lateral Half of Wallflower.

Sepals.—Now look at the sepals below the spreading parts of the petals. Answer these questions. How many sepals are there? **Four.** What is their arrangement and shape? They are narrow, they **stand up forming a tube;** there are **two which bulge out at the base** more than the others and are attached slightly lower down. What is their colour? Green usually, but they are sometimes brown like the petals.

Relations with Insects.—Of course you know why the flowers are attractively coloured and smell sweetly, why the petals are large and spreading. All these things are to attract insects. In the wallflower the spreading petals not only make the flower more easily seen but they afford a **resting place for the insects** when they come for **nectar.**

We must now seek to understand more clearly some of the meaning of what we have observed. You have seen, have you not, that the petal has a long narrow part—the limb. The narrow parts of the four petals stand up straight along with the stamens, but when the sepals are removed you see how easily they fall out of their places. You cannot help seeing that the shape and position of the sepals fit them for forming a **supporting tube** to the parts within, especially the petals.

Why are two of the sepals more bulging at the base than the others? If you remove them you will find, just opposite the swollen bases, moist greenish masses. These are the **nectaries** which produce the honey sought by the insects. The honey collects in these little sacs which form the bulging parts.

Notice then that the honey in the wallflower **gathers at the bottom** of the calyx tube. Insects seeking it must reach it from the top of the tube. That means that only those with long tongues can get it. Many flowers are formed with tubes to **exclude unsuitable insects.** To reach the honey the insects must rub their heads upon the stigma, and in doing this they rub on pollen they have gathered upon some other wallflower. Thus what is called **cross-pollination** is effected, and it gives healthier seed, and better in various ways.

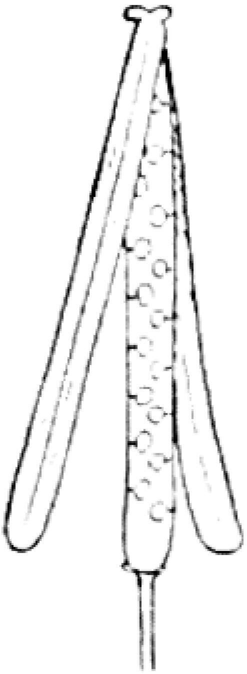
Fig. 6.—Fruit of Wallflower opening for the dispersal of the Seeds.

Seeds and Fruit.—You must examine some growing wallflowers later on when they have seeded and examine the fruit, and notice how it opens and how the seeds are scattered (Fig. 6).

Leaves: Shape and Arrangement.—Now we must look shortly at some of the other parts of this flower. The leaves are very simple, of the shape known as **lanceolate.** That is, they are shaped like the head of a lance—**narrow, tapering,** and **pointed.** Their arrangement is interesting. You will notice that the branch on which they grow is ridged. If you count the ridges you will see there are five. You will also see that the leaves **arise upon the ridges,** and that they are never placed opposite to each other but are all at different levels. You can see that they form a **spiral arrangement.**

Exercise.—Perform the following exercise. Pick off the leaves from a branch, commencing at the bottom, removing them in turn. Lay them out on a sheet of paper in front of you in rows of five each. When you have done this you will have placed over each other the leaves which stand immediately above each other on the stem itself. You will also see clearly how they differ slightly in shape and how the smallest (because youngest) are at the top.

In other lessons we shall observe the various ways that leaves are arranged upon branches and the uses of these. But notice here that the **spiral arrangement serves to keep the leaves out of each other's way.** When a leaf is thrown in shadow its usefulness is greatly hindered, and so we find many arrangements where leaves are numerous for letting them all get a **fair share of light**, as is the case here.

The leaves appear smooth, but **they bear hairs** which are said to be obnoxious to snails and slugs and prevent them eating the plant. These hairs occur on the stem also.

The wallflower is a plant that lives for a number of years. Such a plant is said to be **perennial** (p. 8). It becomes hard and woody in the lower parts, losing its leaves here. But it always has leaves upon it in the upper parts throughout the whole year. You should draw as many parts of the wallflower as you can.

LESSON IV.

PANSIES AND VIOLETS.

[Amongst the common plants found by the waysides, shady banks, woods, and other places in spring and summer we have no difficulty in finding examples of pansies and violets. Common species are the scented violet (*Viola odorata*), the dog violet (*Viola canina*), the pansy or heart's-ease (*Viola tricolor*), and, more restricted in its distribution, the marsh violet (*Viola palustris*). And garden pansies are common everywhere. The lesson will be best taught from a supply of wild plants. Let each pupil have a flower.]

Pleasing Features.—I have here a great bowl of pansies and violets gathered by a country roadside. You, too, have often gathered similar flowers in such places. Before we begin to look at the details of these flowers let us notice how attractive they are. Each flower has its own charm, and some delight us more than others. Violets and pansies are favourites. We are able to keep our interest in them year after year although they are common flowers.

Part of their charm lies in the fact that they are generally half-hidden. Struggling for a place amongst crowded herbage, violets barely manage to lift their heads above it. And their heads are always drooping. Their colours are soft colours, in keeping with their habit of growth. Can you express in words what you feel to be the qualities about these little flowers which please you? Here are some I have heard used—they are sweet, they speak of freshness, they are shy. They have also been termed "modest," which sums up the other three expressions.

The beauty of the violet is not a brilliant, dazzling beauty. Shakespeare very finely describes them as

"Violets dim";

and then, lest this might be thought doubtful praise, he adds:

"But sweeter than the lids of Juno's eyes," which makes us think of the modesty of the drooping flower, and

> "Or Cytherea's breath,"

which is its faint but exquisite fragrance.

You know the delicate fragrance of the little sweet violet—the first violet of the year. This is how at another time Shakespeare wrote when he wished to say it was perfect:

> "To throw a fragrant perfume on the violet
> . . . .
> Is wasteful and ridiculous excess."

Now, whilst we enjoy the perfume of the sweet violet and the winsome colours of the heart's-ease and all the others, it is interesting to remember that **these things exist to attract bees and other insects.** We need not suppose that the bees enjoy the perfume and the colours in the same way as we do. They are drawn to the flowers by them because of that other sweetness which goes along with them, viz. honey or nectar.

The honey is the first thing to the bee, which is attracted to the flower by the perfume, by the conspicuous shape, and the colours.

Examination of the Flower.—We shall now study the flower carefully so that we may learn both how the insects are guided to find the nectar and what service they render in return. You will find that in this instance flower and insect are very closely fitted for each other.

The Shape of the Flower.—I think you should draw this flower, say, a pansy, as you see it from above. You will then understand quite clearly in what way its form is different from that of other flowers you have examined. How many petals are there?—Five. Five is a common number in flowers, and these very frequently are arranged in a star-like form. Flowers whose parts are arranged in a rayed manner are said to have radial symmetry (actinomorphic).

But the five petals here do not produce a radial flower. How is that? If you look closely you will see that the

petals are not all the same shape nor the same size. Neither are they similarly coloured. We recognise two pairs of petals. One pair, which we may call the **upper pair,** another the **side pair,** and an **odd one** larger than the others, the **lower petal.** This flower, instead of having a rayed arrangement, has very clearly a right and left side which you will show in your drawing by putting in a dotted line across the flower between the two pairs of petals and across the large odd petal. This symmetry is **bi-lateral**, or two-sided (zygomorphic).

The star shape and this two-sided shape of which we see in flowers are two ways of attracting the attention of insects to the flower. This two-sided shape has the further advantage of providing a suitable resting place for the insect when it comes. When you have examined other two-sided flowers you will see also that their shape often serves the purpose of guiding the insect to the honey in a way that is very helpful in pollinating the flower.

The Colour of the Flower.—This is different in the different species, and even in the same kind the flowers are not all exactly similarly coloured. You should compare a bunch of pansies and note in what parts the colour varies. Notice that some shade of blue is common to all. Notice, too, that each flower has a **lighter centre.** The lower petal has a bright orange patch at its base across which five dark blue lines pass pointing inward to the centre. The side petals are pale yellow at their bases, and these have each three dark blue lines also pointing towards the centre of the flower.

What is the **meaning of this colour** arrangement? Just as the size, shape, and general colour of the flower serves to attract larger insects from a distance, so, when they are quite close to the flower or have alighted on it, the "eye" and the lines point the way to the honey. These lines have been called **honey guides** because they always point that way.

The Parts concerned in Pollination.—Look now at the back of the flower (Fig. 7). The sepals are slender, five in number, arising each between two petals. They have a short part directed backward from their place of attachment. The most noticeable thing, however, is the drawing out of the lower (odd) petal into a short blind sac or tube—termed **the spur.** If you open this spur you will find hanging downward into it two slender threads (filaments) which you can see grow out from the two stamens next to the lower petal. You may find, too, that

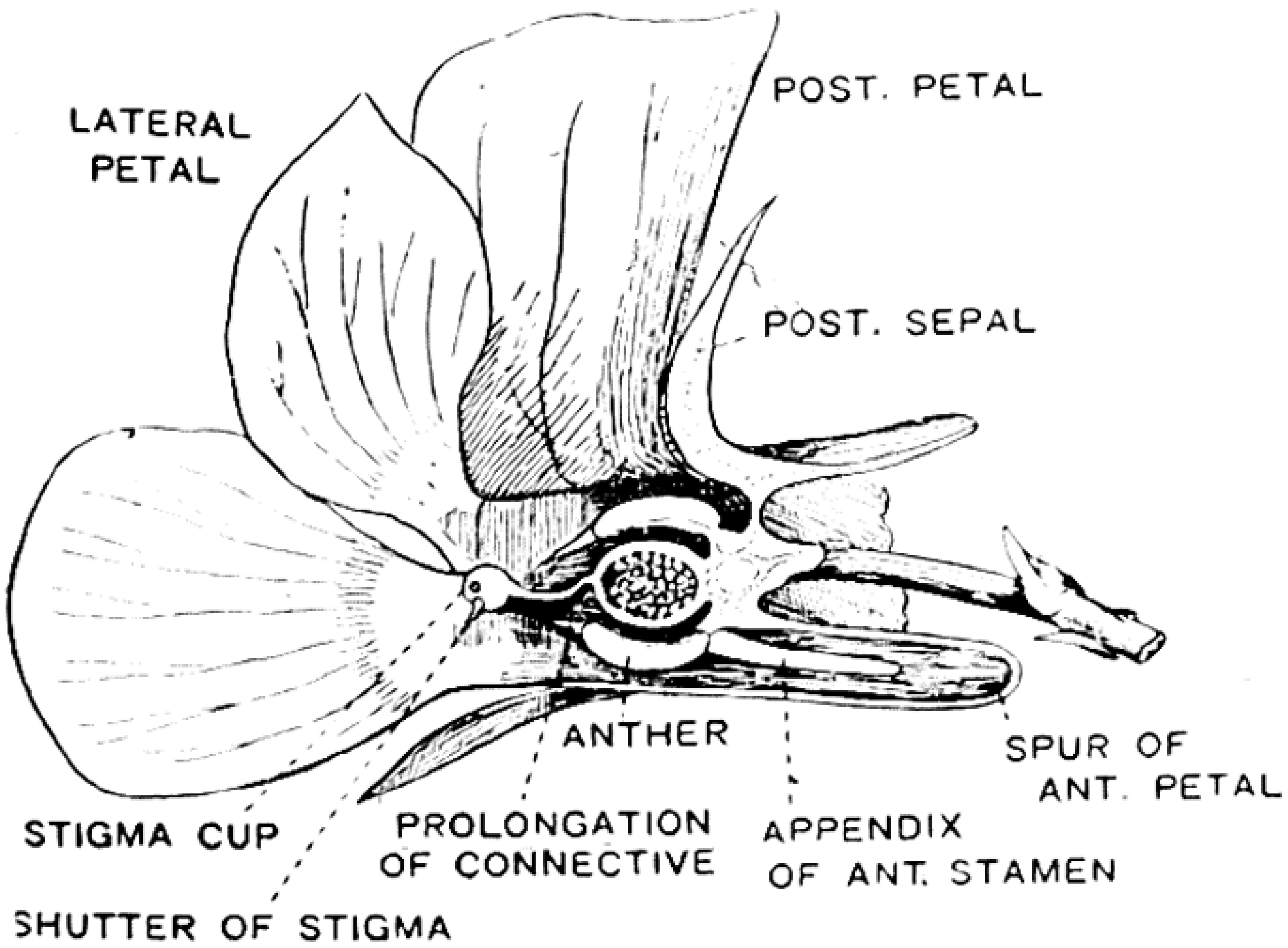

Fig. 7.—Half-Flower of Pansy.

the spur is moist inside. Can you think what is the meaning of this arrangement of parts?

These slender outgrowths of the stamens are the nectaries. That is, they are the parts which form the nectar or sweet stuff which the insects desire. The nectar collects in the spur, therefore the insect must be able to reach down here before it can get it. That means that only insects of a particular kind can procure it. We shall see presently of what kind these insects are.

Turn now to the front of the flower. Notice how small the opening in the centre really is. Notice also that it is made smaller by the edges of the side petals being raised into feathery-like tufts. These arrangements, as well as the presence of hairs elsewhere, serve to keep out small insects which might crawl down the tube, feed on the honey, and give no service in return.

By gently drawing apart the side petals, you can see the green rounded knob-like stigma, hollowed out with a projecting lip on the side towards the lower petal (so-called "shutter"). Below the level of the stigma are five stamens, each with a pointed brownish scale on the top. These scales meet around the pistil, forming a closed box, the **"pollen box."** This arrangement of a pollen box **protects the pollen from the wet.** It also keeps it **secure from small insects**, which might manage to penetrate so far and find it, were it exposed. Owing to these arrangements you are not likely ever to find very small insects about the "eye" of pansy or violet.

The Process of Pollination.—The **kind of insect** which is suited to visit the pansy and pollinate it is a **fairly strong one with a long proboscis.** The process happens in the following way, When a bee seeking nectar probes its proboscis down the tube, its head cannot but touch the stigma. If it has already visited a similar flower **its head will carry pollen,** which will thus be transferred to the stigma, and thus pollination will take place. As it pushes its way into the spur it disturbs the filaments, disarranging the pollen box, and causing pollen to fall on the fore part of its head. When the bee has exhausted the nectar it withdraws its head, and in doing so comes against the under lip of the stigma ("shutter") which in this way **protects the stigma from receiving pollen gathered in the same flower.**

Thus we see these **arrangements favour cross-pollination** and **prevent self-pollination.** The existence of a pollen box, too, tends to prevent self-pollination, as in a drooping flower like this the pollen might otherwise fall upon the stigma.

Very often, owing to the special nature of this method of pollinating, and to the fact that insects may be few in a bad season, many flowers fail to produce seed. If you look at the flowers of the sweet violet, or dog violet, in the autumn, you will see numbers of small **flowers which remain closed.** These are self-pollinating flowers, which therefore do not need to open (cleistogamous flowers). They produce seed which serve to spread the violets in the following year.

Fruits and Seeds.—You must also examine the seed vessels later when the seed is ripe. Notice the way in which they split open and how the highly polished seeds are jerked outward by pressure, and in this way scattered.

For another lesson you should compare the stems and leaves of different violets and pansies. Notice the very large and much-divided leaf-like bodies (stipules) close to the stem at the base of the leaf itself in the pansy. They are so large that they are able to do the work of leaves. Look for them in the violets, and you will find they are much smaller and quite simple. Compare in all the plants the shape of the leaf and the length of the leaf-stalk low down close to the ground and higher up. Look for the "runners," by means of which the sweet violet spreads itself.

Draw all the parts you examine.

The sweet violet flowers very early in the year. What connection has this with the fact that besides being suited to cross-pollination, it also spreads by means of "runners," and has also self-pollinating flowers late in the year? Try to find the answer to this question.

[The foregoing lessons will need careful revision. The teacher should go over the mechanism of pollination carefully, illustrating it by a blackboard diagram. Written answers should be got from the pupils at this stage to questions No. 8, 27, 28, 29, 30, p. 60.]

LESSON V.

PRIMROSES (*Primula vulgaris*).

[Required: A bunch of primroses, leaves, and one complete plant.]

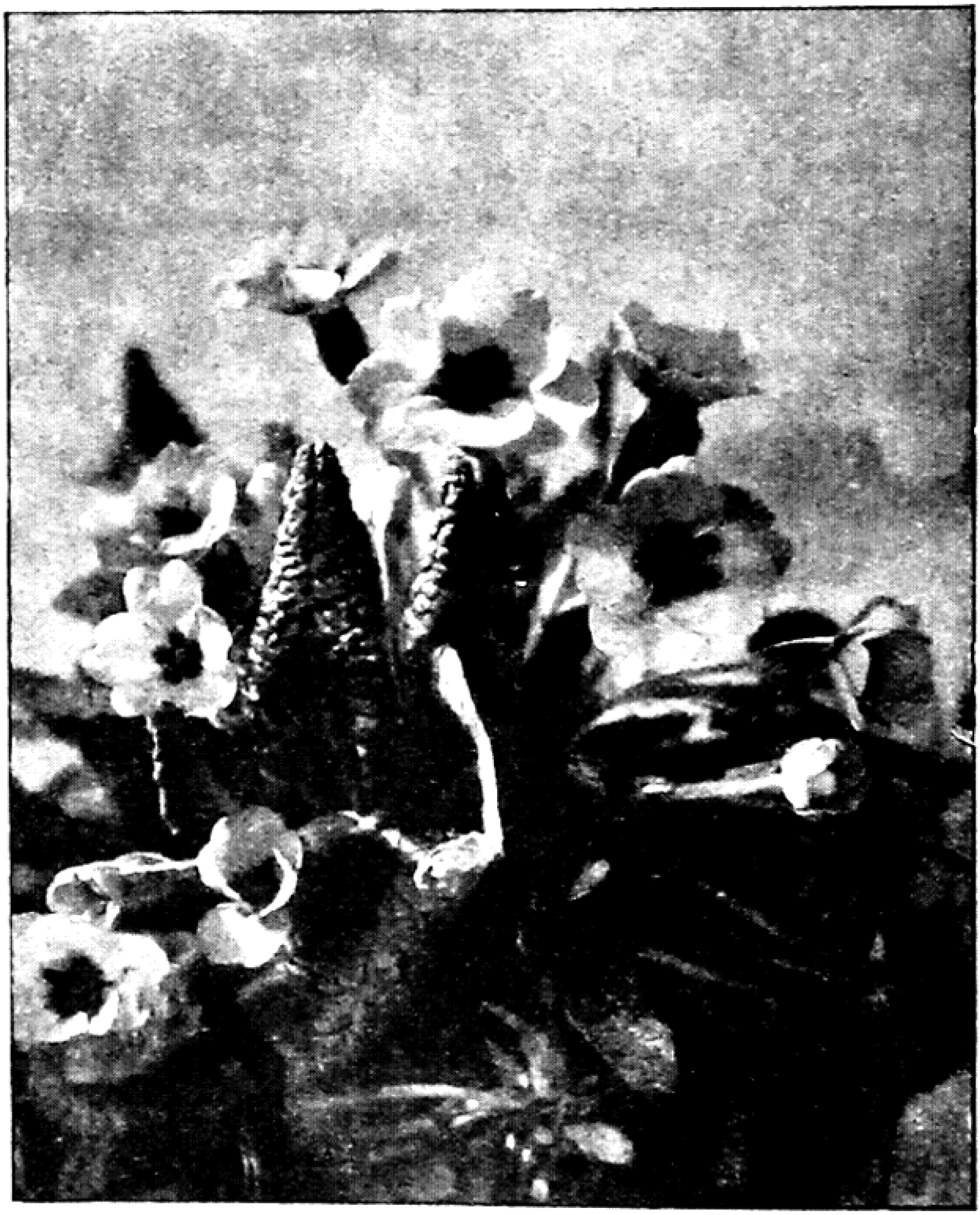

Fig. 8.—Primroses.

Attractions.—Are we not all fond of primroses? There is no doubt we like to see them best of all nestling in glorious profusion in clusters on some wooded bank. It is here we specially admire them.

Let us try to think why we specially delight in the primroses. Spring flowers in general charm us because they are signs to us of the stirring of life, of coming warmth and abundance of light, of more colours in still brighter flowers, of the singing of birds and many other delightful things. Of course you may not think of saying all these things, but you know that spring flowers make you glad, and this is because you are feeling these things although you have not said them.

Whilst this is so, do you not like the primroses for their own sake? You want to pluck a great bunch of them as soon as you see them. I wonder if you could find words to say what they suggest to you—what they make you feel? Two words seem to come to me when I look at them—these words are freshness and cleanness. Perhaps you feel something of this kind too. At any rate not many of you will pass them by unnoticed the first time they appear, without some feeling of delight in the freshness and purity which is suggested by the delicate paleness of the yellow petals nestling amidst the soft and tender green of the wrinkled leaves (Fig. 8).

We have here a bunch of primroses, and also an entire plant dug up. I am going to talk to you for a short time about the primroses, because the more we know about them, the more we shall see about them each year as they appear. It will never after this, I hope, be said about any of you as it was of Peter Bell:

> "A primrose by a river's brim,
> A yellow primrose was to him,
> And nothing more."

The Flower.—Now let us look at the flower first. It is one of our early flowers. This doubtless means that a primrose is a **hardy plant.** It can grow and blossom with much less heat and light than most plants can. While there is no doubt about this, we must remember also that it passed the winter with food materials stored away in this creeping stem which grows below the ground,

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and that these are ready to be built into the growing plant as soon as the spring appears.

I wonder if when you have looked at a bunch of primroses you have discovered that there are **two kinds** of them (Fig. 9). I shall give you one each from the bunch here, and you shall soon discover, if you have not already observed it, that there are two kinds. Look each of you at the centre of the flower. It is convenient to call the centre part the "eye." The "eye" of flowers is very frequently differently coloured or marked from the rest of the flower, and it is so here. You have noted this in the pansy. Both kinds of primroses have an orange-coloured ring forming the margin of the eye.

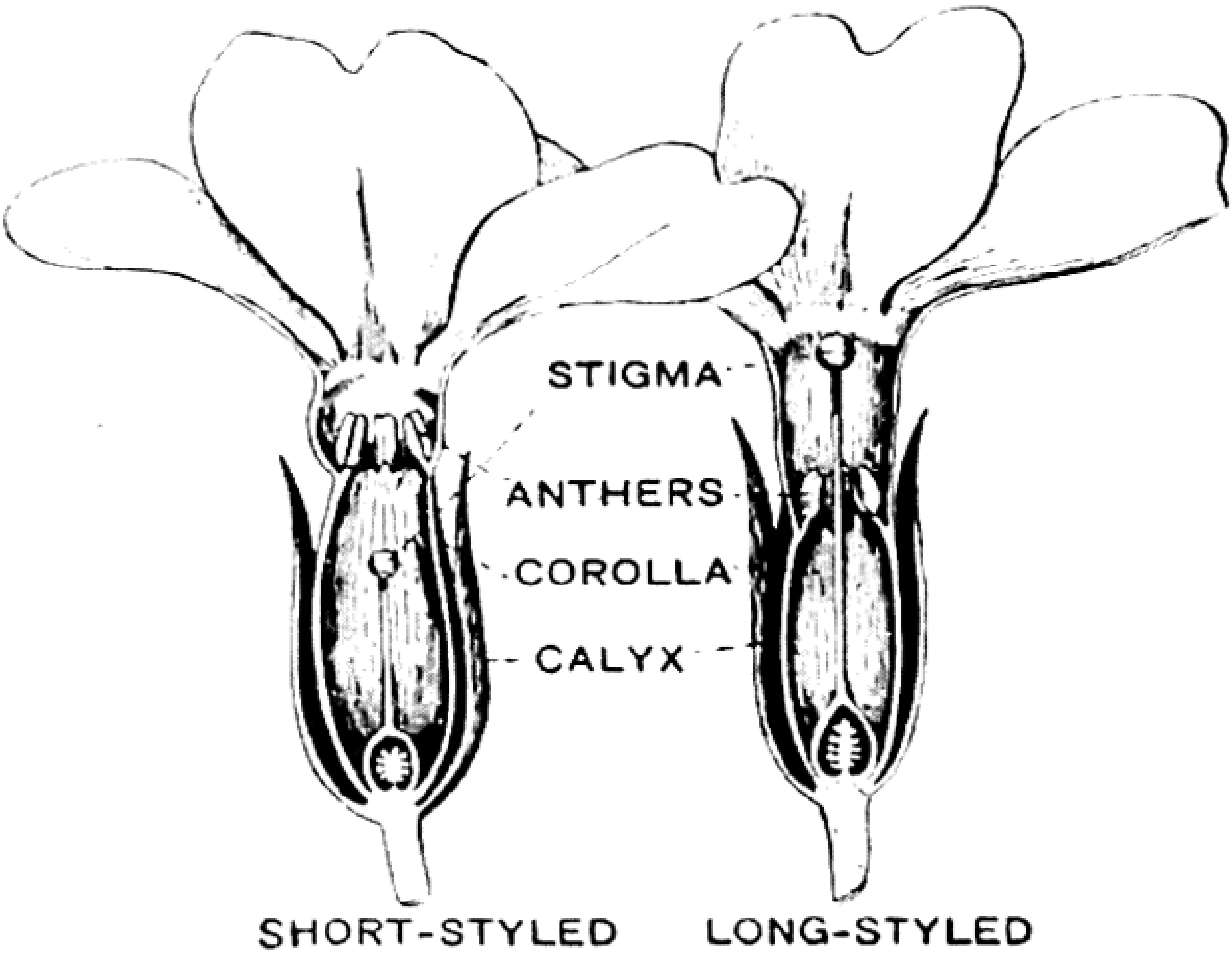

Fig. 9.—Flowers of Primrose.
(Short-Styled = Thrum-Eyed; Long-Styled = Pin-Eyed.)

Now in some primroses you see a small green knob, like the head of a pin, right in the centre of the space within the ring. This is the stigma of the flower, and those primroses which show it in this position are called **"pin-eyed." You do not see any stamens,** but if you were to open the tube formed by the lower parts of the petals you would find them attached—one opposite the middle of each petal—about half-way down the tube. I shall open one and show you this. This then is the "pin-eyed" primrose.

In other primroses we cannot see the stigma at the top of the tube. But **now we see the stamens** instead. These are attached just like the stamens in the other kind of flower, but as you notice at the top of the tube—not half-way down. When I open a flower of this kind if I find the pistil is so short that **its stigma reaches only half-way up the tube,** it is just a case of the positions of stamens and stigma being reversed in the two kinds. This second kind is called **"thrum-eyed,"** and of course you can see why.

We have learned in other lessons that it is a good thing when the pollen of one flower of a particular kind is deposited on the stigma of another flower of the same kind. The seed is stronger and there is frequently more of it. Now if you think for a little you will see that where there are two kinds of flower in the same kind of plant, there will be three different ways in which seed may be got by cross-pollination. These are:—

(1) Pollen of pin-eyed flower upon stigma of pin-eyed-flower.

(2) Pollen of thrum-eyed flower upon stigma of thrum-eyed flower.

(3) Pollen of pin-eyed flower upon stigma of thrum-eyed flower, or pollen of thrum-eyed flower upon stigma of pin-eyed.

In (1) and (2) the pollen and stigma *may* belong to the same flower. This is self-pollination. All the other cases are cases of cross-pollination, and of them all it has been proved that seed got by the method in (3) is the best seed.

The Process of Pollination.—You can guess, I think, how the cross-pollination is carried out. Insects, bees for example, visit the primroses for pollen and honey. When they dip their tongues down the tube their heads and tongues will always touch the same parts in each case.

And in passing from a thrum-eyed form to a pin-eyed they will carry pollen on to the stigma with their heads. In passing from a pin-eyed to a thrum-eyed they will again transfer pollen from the one kind to the stigma of the other, this time upon their tongues half-way down the tube.

The use of the Tubular Corolla.—Notice that the petals are united to form a tube, and that the tubular part is surrounded by the sepals which are erect and united in the same way. In plants of this kind we generally find that small insects with short tongues which might rob the plant of honey, and not give any service in return, are prevented from reaching it, owing to the length of the tube. In what other flower have you seen a similar arrangement? (p. 16).

The Ovary.—If we open the tube we can see very clearly the central rod-like pistil with its ball-like base. This ball is hollow, and in the centre you will find a rounded **mass whose surface is covered with the ovules**—the bodies which later become seeds. When the seeds are ripe the enclosing capsule splits into five parts. This is interesting when we notice that all the other parts of the flower are in fives—sepals, petals, and stamens.

Hairs.—The primroses grow in clusters upon fairly long stalks. Notice the colour and soft hairiness of these stalks Do you know how useful hairs generally are upon plants? Although plants cannot actively defend themselves from the attacks of animals, there are many arrangements about them which do a great deal to protect them. One of the commonest of these is the covering of their surfaces with hairs. Hairs have various uses, one of which is to present difficulties to the smaller creeping animals which would crawl up the plants and destroy or rob the flowers of their substance. In the primrose they serve this purpose.

Compare with Cowslip.—If you trace the flower stalks downward on a complete plant by carefully removing the leaves you will see that the flowers arise together in a cluster. They really arise from a small outgrowth upon the creeping stem. You may think of this outgrowth as a branch which has not grown except a little way. The cowslip is a plant very similar to the primrose, and you should examine it also. There you will find the flowers clustered together also, but in this case the branch (scape) from which the flowers arise is long, whereas in the primrose as we see it is quite short.

Drawings.—You should draw a primrose flower of each kind and a pistil with its pin-head-like stigma. This should be done during the lesson.

Leaves.—The leaves of the primrose are well worth studying also. I think you will see the interesting things about them best if you **carefully draw one.** As you draw it notice the following :—

The **shape** of the leaf—termed **obovate**. Narrow at base, broad at tip.

The **wrinkled surface,** darker green above.

The **midrib groove** on the upper side, gradually widening to the base, whitish with long white hairs.

The **paler under surface,** thickly covered with whitish hairs.

Notice that the hairs here help to prevent water leaving the plant by the openings on the surface of the leaf too rapidly.

In another lesson we shall examine an underground stem and roots like those of the primrose (p. 33).

LESSON VI.

THE LILY OF THE VALLEY (*Convallaria majalis*).

[This flower, which is common in gardens, also grows wild in a few places in this country. It flourishes best in chalky soil. For lesson purposes it will be advisable to have a complete plant, as well as flowers and leaves, for pupils' use.]

Attractions.—We have noted in the case of other flowers we have studied the various points about them which may be called their chief attraction. This flower displays several interesting and pleasing features. Let us try to name them. While it is a flower of a **delicate and graceful form** is it not also one which possesses a deliciously **fragrant odour?** It is not easy for us to say which of these is the more pleasing. Some of you may value the attractive form of the flower the more, and others delight more in its refreshing smell. But we are all agreed, are we not, that both together make the lily of the valley a **charming flower,** which delights our senses of sight and smell, and which we love to see both in the garden and in our homes. Will you just **look at the**

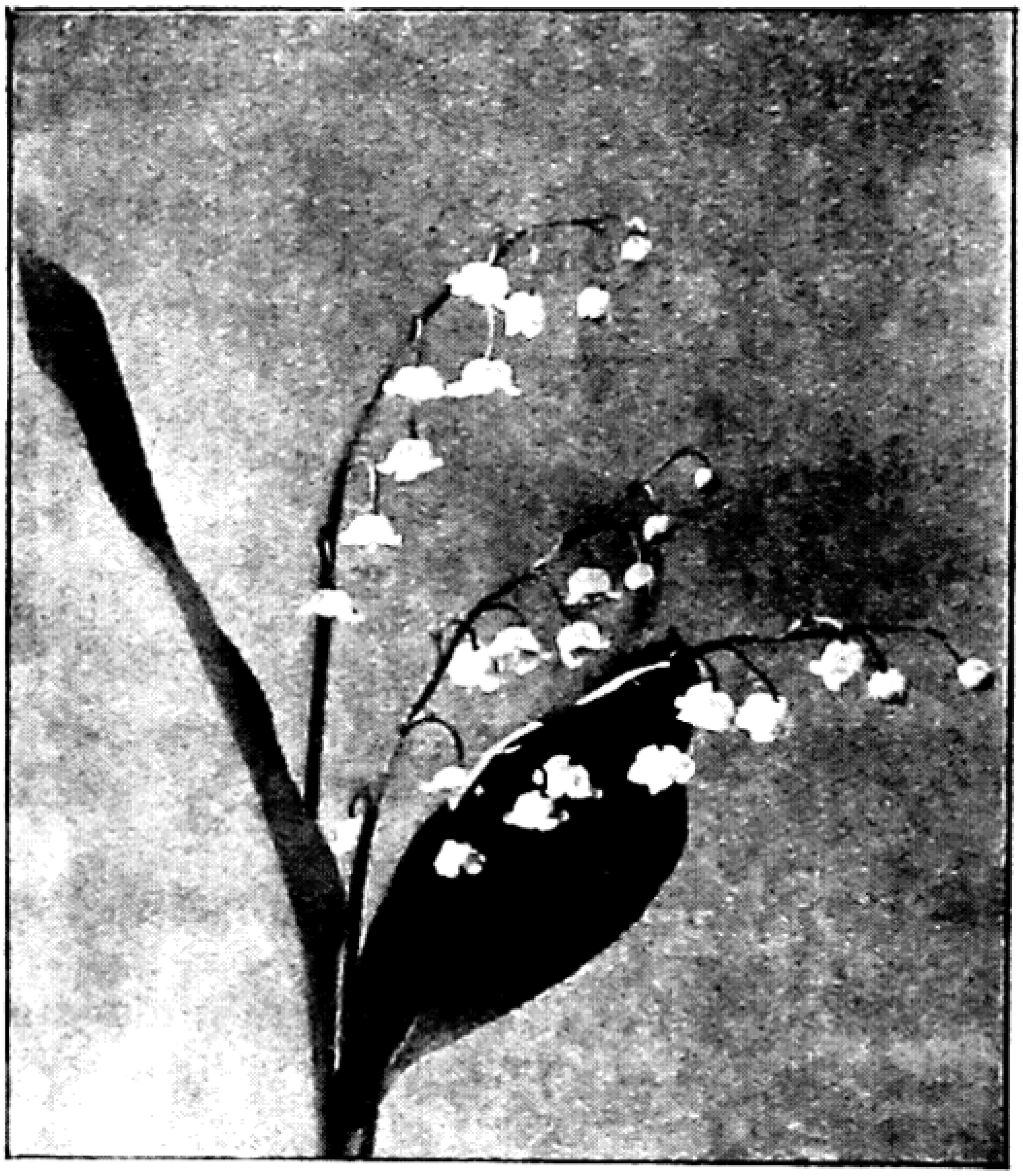

Fig. 10.—Lily of the Valley.

flower for a little, smell it, and then **write down** in your note-books in **your own words** what you think are its pleasing features.

Detailed Examination.—Now we shall look at the lily of the valley more particularly. We shall begin with the **flowering stem,** and what it bears. What is the shape of this stem? It is ridged, or angled, not rounded. It is smooth and green in colour. What do you find upon it? A series of **short stalks** (pedicels), each bearing a **single flower,** and at the base of each of these stalks a little **scale-like leaf** below. A small leaf in this position below a flower stalk we have already learned is called a **bract** (p. 7). What do we call a collection of flowers borne together upon a single stem such as we have here? Such a collection of separate flowers is called an **inflorescence.** Flowers are clustered in many different ways upon plants, and each different kind of grouping requires, of course, a distinguishing name, but we shall not begin to learn these names at present. We shall, however, look at the arrangement itself.

The Inflorescence.—Count the number of flowers upon a single stem. About twelve is common, but sometimes there are as many as sixteen. Compare the lengths of the flower stalks. Those nearest the bottom are longest, but there is not a great deal of difference in the length. How are they arranged? Look first at the bottom flower stalk, then at the next in order, and then at the next higher, and so on. As you do this you discover that the flowers are arranged in an **open spiral** ascending the stem. With this arrangement you would expect them to look outward on all sides of it. Do they do so? No, the **flower stalks are twisted,** so that the **flowers all turn more or less to one side.** Notice, too, how they **curve downward** so that the individual **flowers all droop.** Now look at the whole inflorescence again and notice the general result of all these things. There are a good **many flowers within a short space;** for example, you may count as many as fifteen upon a portion of the flowering stem four and a half inches long, and yet they all stand clear of each other. There is **no overcrowding.**

Notice, too, that although the individual flowers are small, the inflorescence as a whole is quite noticeable. When **flowers are small** they are very commonly **grouped together** in more or less close inflorescences as here to render them more **conspicuous.**

The Parts of a Flower.—Now we shall look at a single flower. It is pure white in colour, and hangs downward upon its curved flower stalk **(pedicel).** This flower is **always open.** Count the points, or lobes, upon its margin. There are six, corresponding to the six lobes of a lily or hyacinth. What do you see within the flower? Six short stamens set close against the pistil and behind the stigma. The pistil is swollen into a ball-shaped ovary. Is the **ovary** within the flower, *i.e.* above the perianth, or outside, *i.e.* below it? It is **above the perianth.** Name a flower you have seen lately in which the ovary lies below the perianth. Narcissus. **What is the shape of the stigma?** It is three-cornered. If you will now **compare** this flower with the daffodil or narcissus you will see that they **agree in number of parts**, but **differ in the position of the ovary.**

Insect Visitors.—Have you noticed the bees visiting this flower? Although it is often well hidden among its leaves, the bees find it. How are they guided to it? By their sense of smell. **They collect pollen** from it. This flower **does not have free nectar.** In going from flower to flower the bees will carry pollen on their bodies from one flower to another, and cross-pollinate. Should the flower not be visited its pollen may fall on the stigma, owing to the drooping position of the flower. Thus **self-pollination may take place.**

Other Parts.—If you trace the flowering stem downward you will find it surrounded by scale-like purplish leaves. It arises from the side of a very short branch which bears the leaves.

Examine the **leaves.** Answer the following **questions** about them :—

What is their shape? What is the difference between their upper and under surfaces? What is the arrangement of the veins? How are the leaves arranged? In groups of two or three spirally placed, so that they stand at different levels. What is the shape of the leaf stalks? They are tubular at the base and clasping (sheathing) close to the leaf blade. Which leaf stalk is outermost? The lowest, *i.e.* the oldest one, so that the youngest leaves are highest up. What will be the effect of this form of leaf arrangement when rain falls? The rain will be collected and guided slowly down the leaf stalks close to the underground stem and roots below.

Within the tube made by the leaf stalks is the point of the short reduced branch on which they grow. Around the green leaves there are scale-like purplish leaves.

Examine the slender **underground stem** (rhizome). On it, near the bases of the leaves, you may see the marks left by former leaves (**scars**) and ends of former flower-bearing branches. Notice the **bunches of roots** at regular intervals (**nodes**) upon this creeping stem. Does the underground stem branch? Yes.

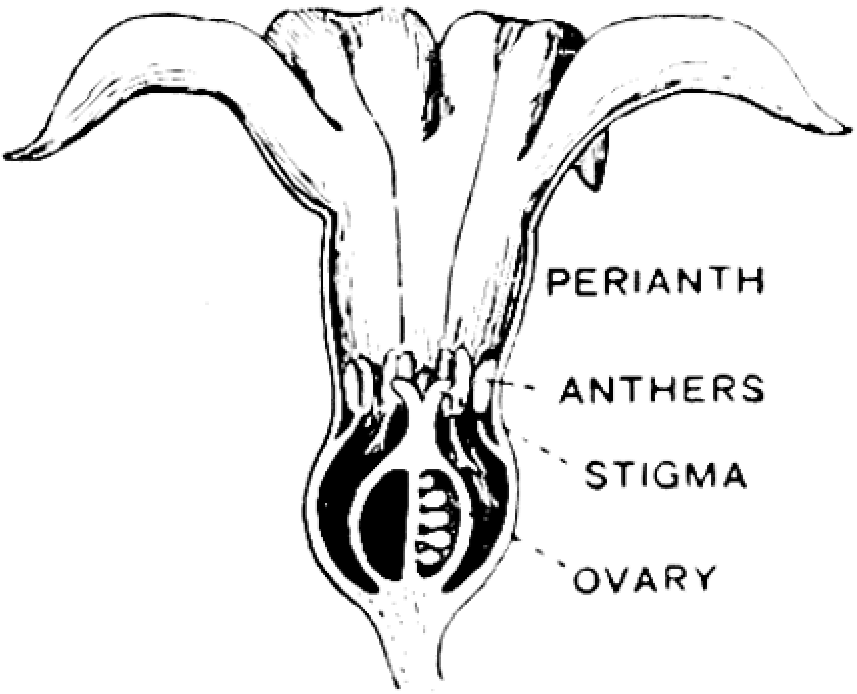

Fig. 11.—Half-Flower of Hyacinth.

Propagation. — How does the lily of the valley spread? By seeds formed in the ovary. The fruit is a berry. It also spreads by the growth of the **rhizome,** which remains living stored with food through the winter. This plant is another illustration of a perennial.

Another lesson, upon similar lines might be given upon the flowers of wild hyacinth (*scilla nutans*), tulip, or lily.

LESSON VII.

RHODODENDRON.

[This is a plant we are not likely to be able to exhibit in school, but pupils will be familiar with it in parks and gardens. They should be asked to examine plants budding

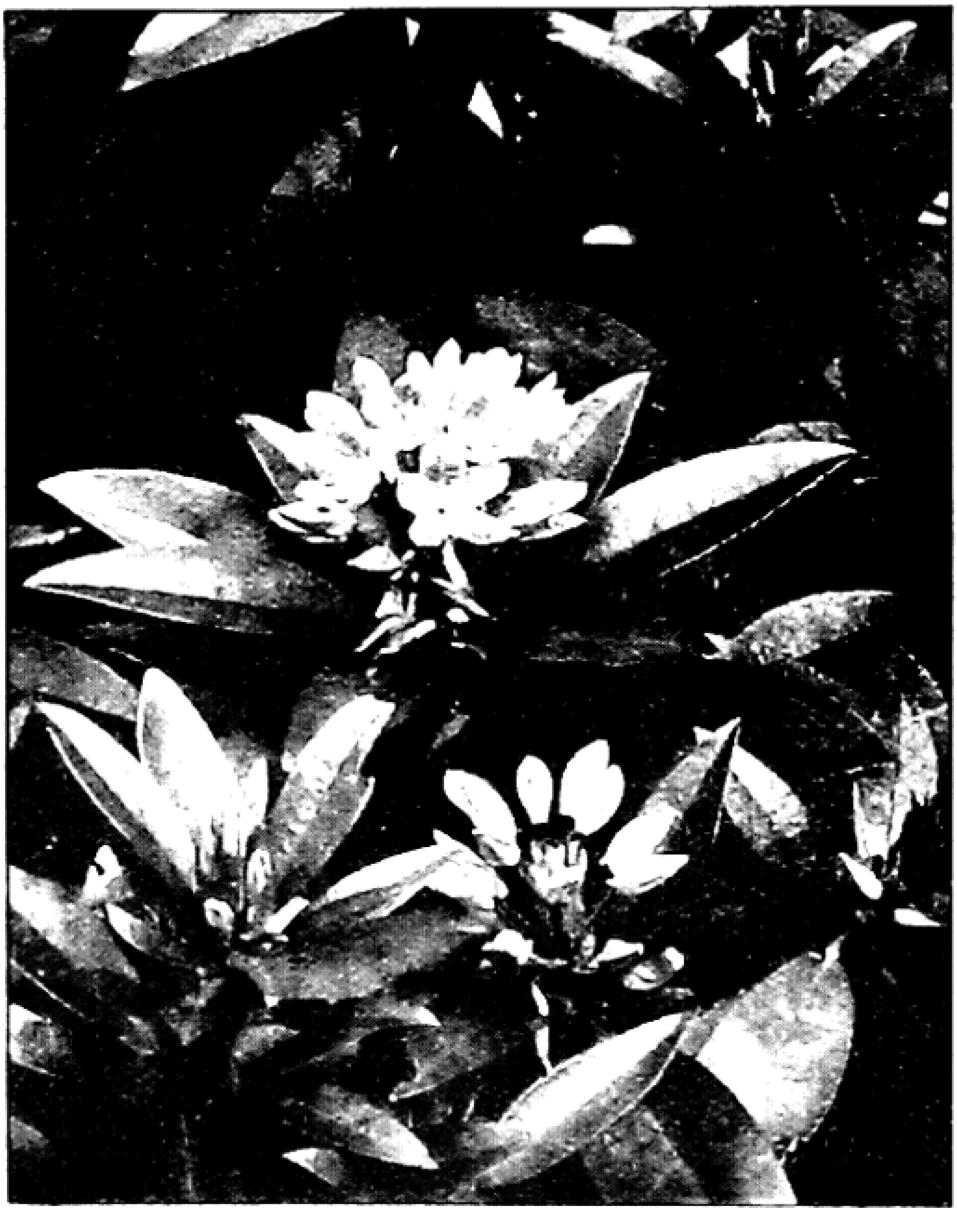

Fig. 12.—Rhododendron.

and in flower, and make notes upon their appearance. Some leaves, flowers, and fruit can be got without much difficulty for examination.]

Questions upon Observations made.—How do you describe the **stem and branches** of this plant? Are they soft and easily bent, or are they hard and woody? If you cannot answer this question now, you must again examine a plant at the first opportunity, so as to see for yourselves. This is a woody plant.

I am sure you can answer my next question. Is this plant **ever bare of leaves?** No. Through the winter as well as summer, leaves are to be found upon the rhododendron. It is an **evergreen.** That is, its leaves last for more than one year; and while some are shed from time to time, they are never all shed at the same time.

A Shrub.—A rhododendron plant is called a **shrub.** It is woody like a tree, but it does not grow so tall as most trees, nor like most trees does it lose its lower branches, but keeps even those which rise from quite close to the ground.

Attractions.—A well-cared-for rhododendron is a beautiful and attractive plant. Can you name its special attractions? Firstly, it flowers early in the year—at any rate some varieties do—when other flowers are scarce. Secondly, its blossoms are always handsome, whatever the colours may be, whether pure white, or rich glowing red set in a background of fresh glossy green leaves.

The Inflorescence.—Here are small branches, having fine big bud-like structures. What do these resemble? Are they not like cones? Notice the spiral overlapping arrangement of the scales. Can you tell what will come out of this "bud"? Some of you think a flower will. Now the best way to obtain an answer to this question is to watch the unfolding of similar ones upon the shrubs. If you do so, you will discover that this is not an ordinary flower bud, but that out of it there comes a number of flowers—a whole inflorescence.

Note that this grouping of the inflorescence into a close massed cluster renders the plant very conspicuous.

The Flowers.—Examine the flower. There are five free sepals, five **united petals.** Are they equal in size? How many stamens? Ten. There is a pistil made up of five united carpels, the ovary has five separate chambers. Make a drawing of a flower.

The Leaves.—Examine the leaves. Notice the shape. What name is given to this form? **Ovate.** Draw a rhododendron leaf. Describe its texture, and colour above and below. Why are these leaves strong and leathery? Why have they got short and tough stalks (petioles)? Because they have to withstand both the cold weather and the rough winds of winter in their native haunts.

In a dry season the leaves of the rhododendron curl back at their edges. Can you explain this? This checks the loss of water through the openings (stomata) upon the leaf. These openings are mostly upon the under side of leaves, and the curling of the leaf shelters them from drying winds. In winter the leaves bend downward. Why?

Note also the arrangement of the leaves, remembering the necessity for them all being in the light. Do you think the arrangement in this plant serves this purpose well? Make a simple drawing of a cluster of leaves upon a branch showing the characteristic whorled appearance which they present.

A lesson on the Flowering Currant (*Ribes sanguineum*), another shrub, might be given as an alternative.

LESSON VIII.

SUGGESTIONS FOR A REVISION LESSON ON THE GENERAL FUNCTIONS OF PLANTS.

[For this purpose any common wild plant, *e.g.* Shepherd's Purse will do quite well.]

The Root.—Pass over all details of structure. What are its functions?

(*a*) It holds the plant in the soil. Obviously **fixation** is an important function of the root. Notwithstanding the fact that there are plants endowed with powers of locomotion, and animals that are fixed and sedentary, this is one of the biggest contrasts in mode of life between animals and plants. Plants are in general habits stationary organisms. This may be pointed out to pupils.

(*b*) Secondly, the root is **absorptive.** It absorbs mineral ingredients dissolved in water from the soil. This is also an important fact **distinctive of plant life.** Emphasise this. Refer to growth of plants in water cultures* (Fig 13).

These are the chief uses of roots, but we may mention one other which although a secondary one is of common occurrence.

(*c*) Some roots are utilised for the *storage* of reserve food products, *e.g.* those of turnip, carrot, lesser celandine, dahlia. Get the children to name a list.

The Stem.—(*a*) Plants have direct relations with the sun, and the first function of a stem undoubtedly is to **hold up the parts** of it **which deal in sunlight**, viz. the leaves. They also need air (carbon dioxide), and here again the stem, by means of its length and its branching, **spreads out to the atmosphere the leaves** which are more especially reacting to it. And the flowers must not be forgotten, which in most cases must for fulfilment of their functions be exposed to insects, to wind, or to other fertilising agents.

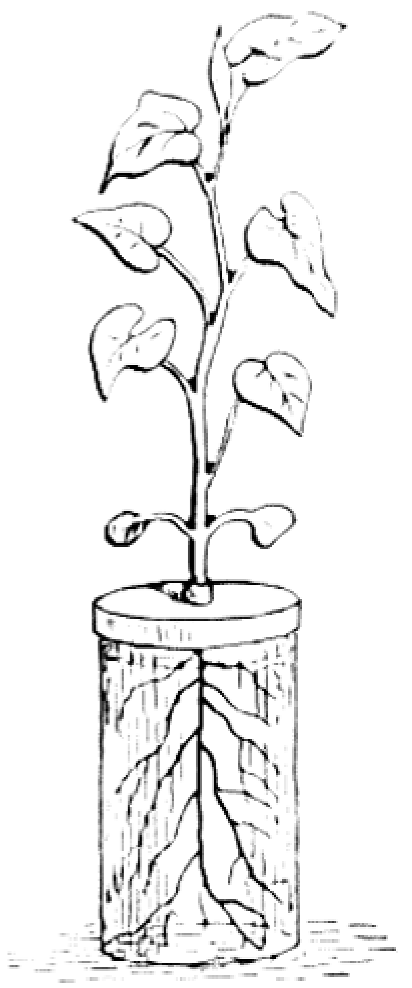

Fig. 13.—A Plant of Buckwheat grown with its Roots in a Culture-solution.

But here also some secondary functions may be noted.

(*b*) Along the stem of necessity there passes **the crude sap** absorbed by the roots from the soil. This passes to the leaves, returning along the stem again as **elaborated sap** (food) to the whole plant.

(*c*) Sometimes the stem of a plant is used in a more or less specialised form to **store reserves** of food stuff, *e.g.* as **tubers, corms,** and **rhizomes.**

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* The teacher who can find the apparatus, etc., and wishes to demonstrate the growth of plants in water cultures will find all the needed information as to methods, etc., in Caver's *Plant Biology*, p. 115, or *Practical Botany*, p. 164.

(*d*) Also in some cases for the multiplication of the plants as **runners** or **rhizomes,** above and below the ground, *e.g.* the creeping buttercup or wood anemone.

The Leaf.—This important organ—

(*a*) **elaborates food,** decomposing carbon dioxide in sunlight;

(*b*) **builds up organic substances**—starch, sugar, etc.;

(*c*) **transpires excess** of moisture from the plant;

(*d*) **takes in oxygen** for respiration of the tissues.

The Flower.—The **production of seed** is the primary function of the flower. Get pupils to name the uses of the chief parts in a typical flower.

The Seed.—The function of the seed is the **continuation of the species.**

Summarising, we may say that the life of a plant is manifested in its reacting (in a characteristic manner) to

Moisture,
Minerals,
Oxygen,
Carbon dioxide,
Sunlight.

Put more simply we say that, in order to grow, a plant needs those things.

It is worthy of note that the numbers of plants are so great and their distribution often so crowded that there is competition for these universally distributed elements. This is the "struggle for existence." It seems strange that air and sunshine, for example, in which the world is bathed should be denied or restricted in amount to any living thing. Yet careful observation will show how plants may put each other in the shade and in this way impair their power of using the air in food making. Try by means of simple illustrations to get the pupils to realise this. In the struggle for the best places very many "adaptations" exist. We must constantly look out for these in the plants which we study.

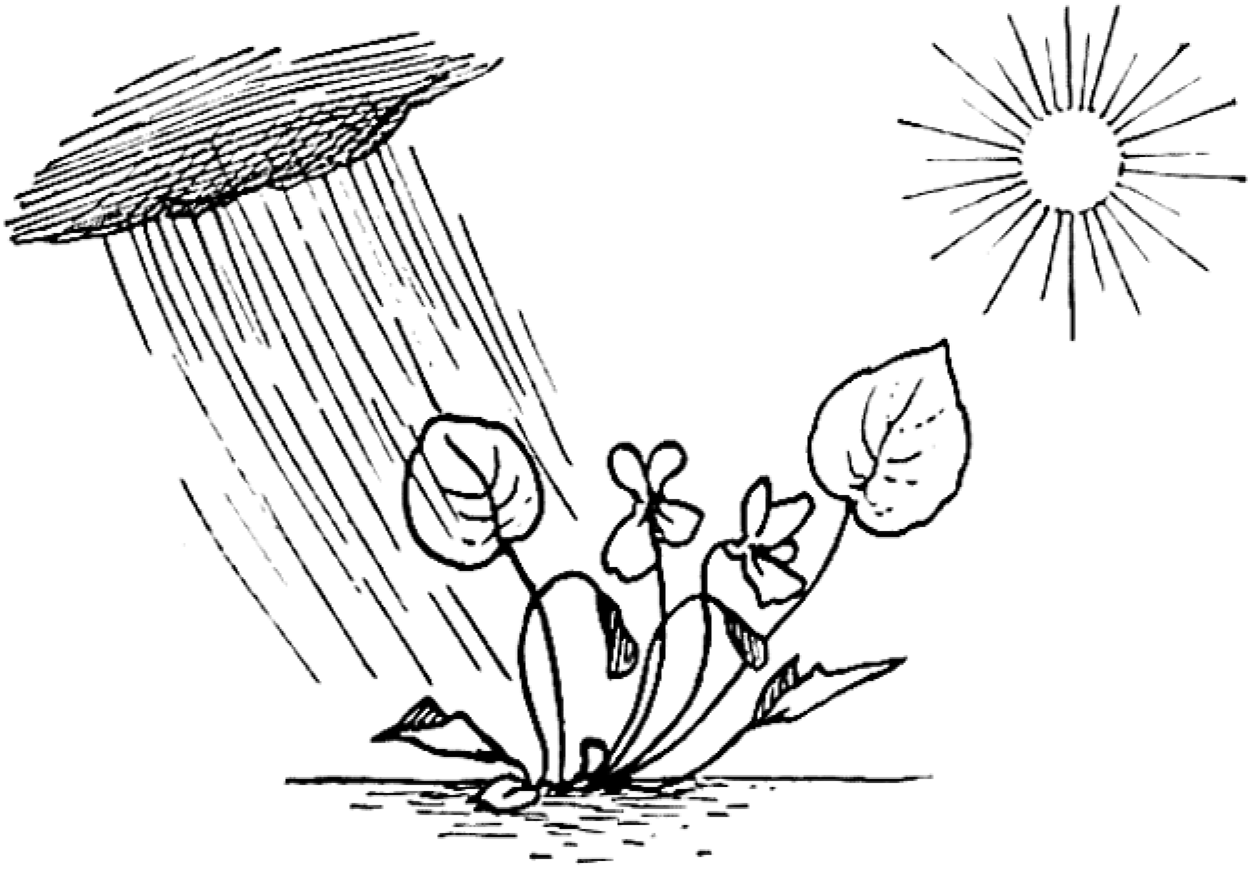

Fig. 14.—A Diagram to illustrate the needs of a Plant.

Along with the pupils make a diagram to represent the foregoing summary (Fig. 14).

LESSON IX.

THE FLOWERS OF TREES IN SPRING.

[Twigs of as many common trees flowering in spring as possible should be obtained. Further, a visit to trees in the neighbourhood should be made in connection with this lesson and the attention of the pupils directed to these. This opportunity should be taken of making the pupils familiar with the trees by name. Indeed, the complete lesson cannot be given unless there are at least a few trees which can be appealed to. The teacher may wish to include in these studies tree flowers which cannot all conveniently be studied at the same time. In such a case they may be taken as they appear, and the facts brought out summarised after the manner of the lesson given below. There is ample material for a series of lessons.]

Catkins.—Have you been watching the appearing of the flowers upon the trees during the past few weeks?

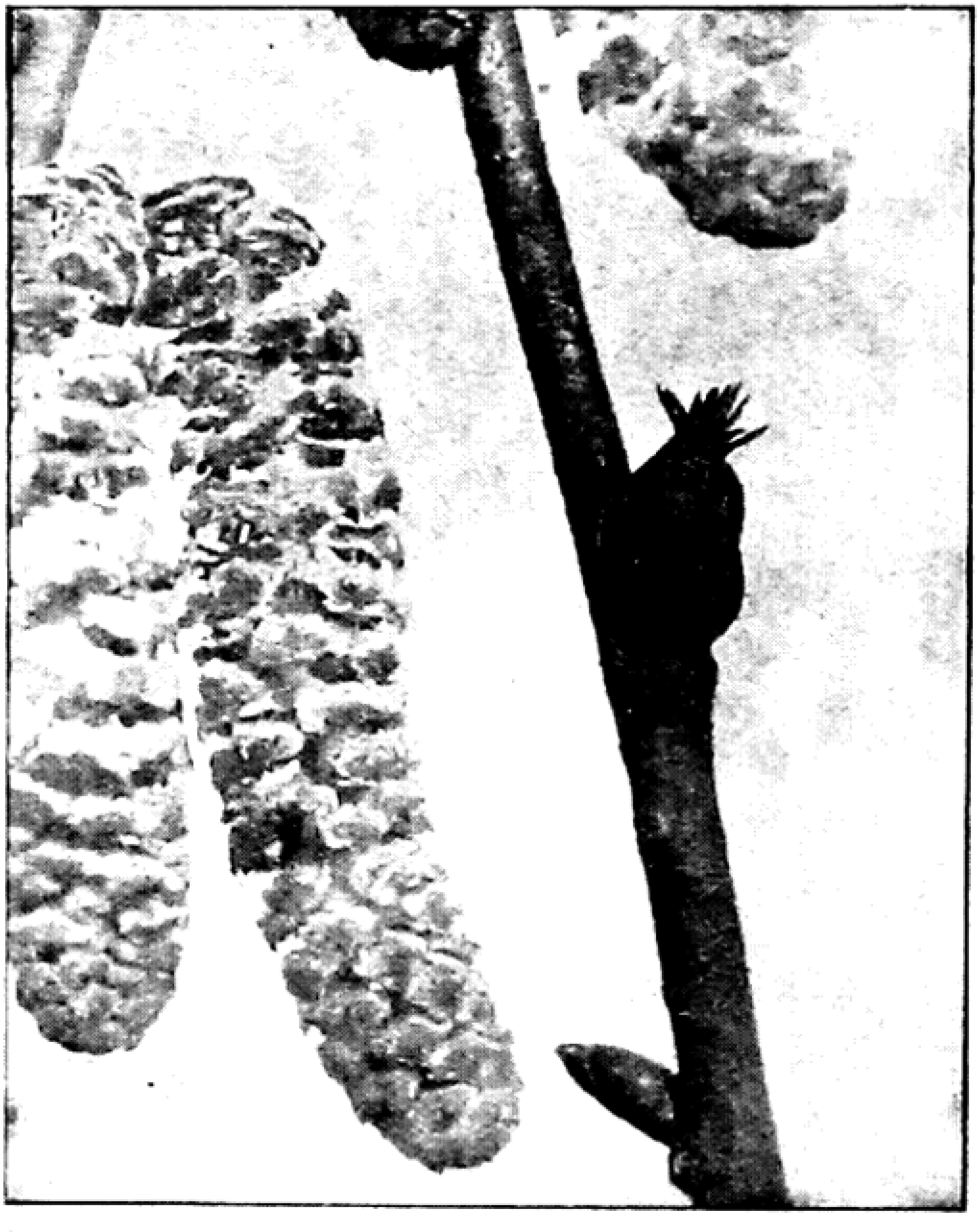

Fig. 15.—Catkins of the Hazel. Male (drooping) on left, Female (erect) on right.

In most cases these flowers are grouped in **catkins.*** Here are some of the catkins which are to be seen in spring—hazel, alder, willow, poplar, birch. How many of these do you know? (It should be possible for the teacher to exhibit one or two of these at least, *e.g.* a willow, hazel, or birch).

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* A Catkin is a close-set, usually drooping, more or less elongated inflorescence (spike), in which the flowers are unisexual.

These catkins, of which you will notice in birch and hazel two kinds, large and small, and in willow also two kinds both about the same size but differing in colour, are clusters of very small flowers. Look closely at any one of them and you will see the small flowers, although without a magnifying glass you cannot see all the parts of which the flowers are made up. Perhaps at another time you will with the help of a good lens see clearly all the important parts of some of these flowers. Meantime we shall try and find out some things about them without one.

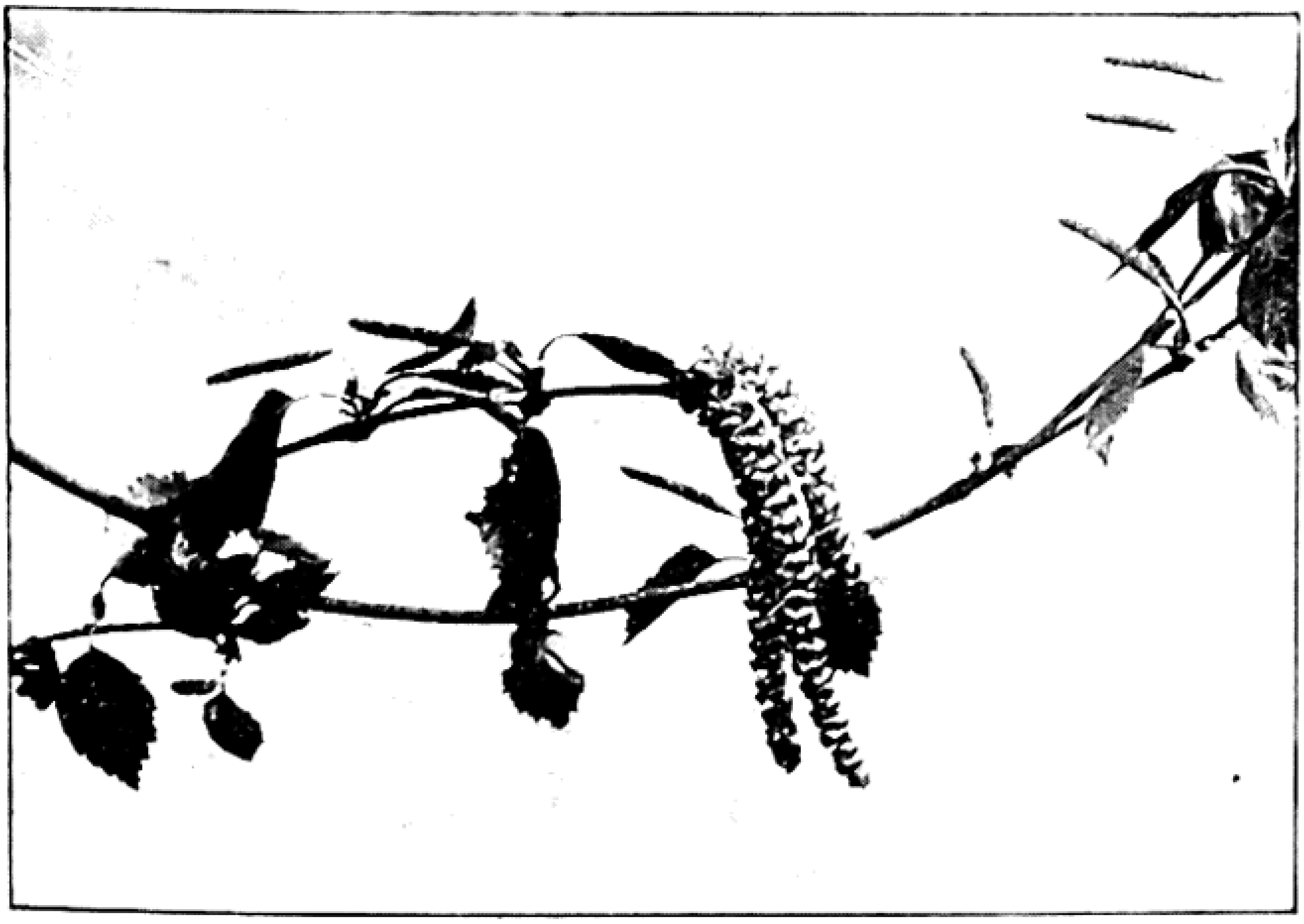

Fig. 16.—Catkins of the Birch. The slender ones of erect habit are Female, the longer drooping ones are Male.

We have noticed there are **two kinds of catkins** to each kind of tree (Figs. 15, 16, 17). Can you say what this means? We call them male and female. The flowers of the male catkin produce **pollen** and those of the female produce **ovules,** the bodies which have the property of becoming seeds when acted on by suitable pollen. Examine a ripe catkin of the hazel or other suitable tree—(one of the long drooping ones)—shake it and you will see the pollen. What are the golden yellow bodies upon one kind of willow catkin? These are the anthers which contain the pollen. Look now at the smaller erect bodies upon the hazel twig. Do you see these beautiful **crimson feathery tufts** upon the top (Fig. 15)? Can you think what they are? These are the **stigmas.** You may manage to see the stigmas upon the smaller catkins of the birch, but they are not so conspicuous (Fig. 18). In the willow they are not so spreading, but the catkin is more open (Fig. 17).

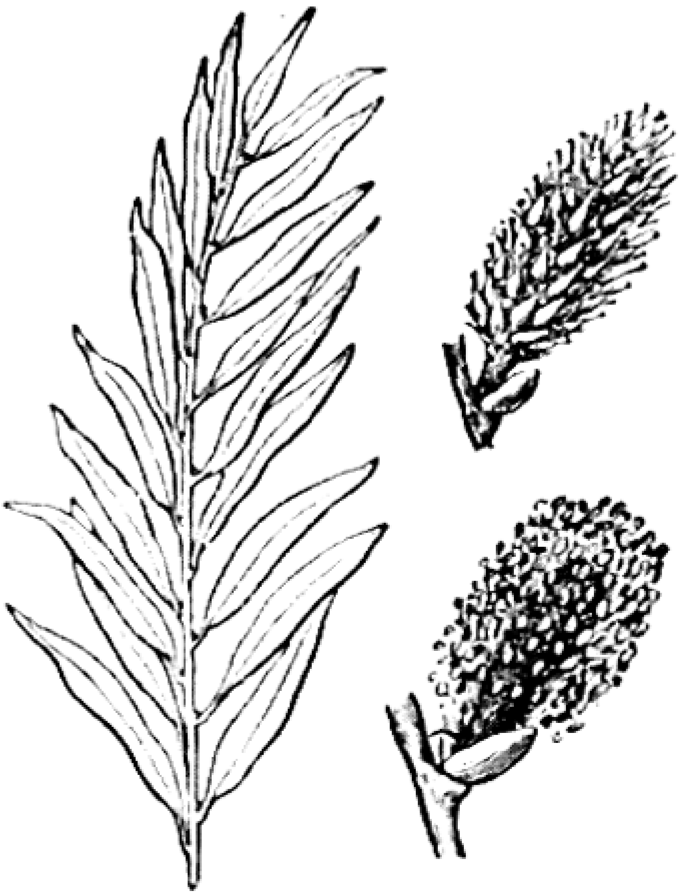
Fig. 17.—The Willow, with Male (lower) and Female (upper) Catkins.

Now you should draw some of these twigs with their catkins. As you do so you will become more familiar with the fact that except in the case of the willow, all these spring catkins which bear pollen, droop. They are described in books as "pendulous," *i.e.* hanging. On the other hand the stigma bearing ones are erect.

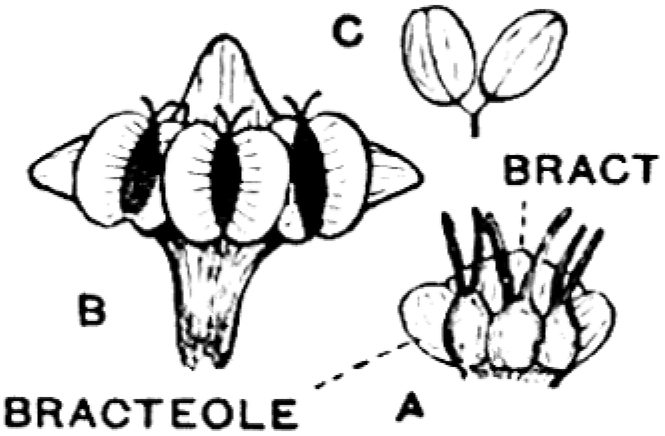

Fig. 18.—Birch.
A, Female Flowers in Axil of Bract; B, Fruiting Scale, with three fruits; C, Stamen from Male Flower.

The Work of the Wind.—How does the pollen reach the stigmas on to which it has to fall before it can reach the ovules? It is borne by the wind. Think of this for a little and you will then understand why the pollen bearing catkin produces abundant pollen, why it hangs down tassel like and sways in the wind, why the stigma bearing catkin is erect, why the stigmas are exposed and spreading and why they are hairy. Be sure you can answer all these questions.

The Case of the Willow.—The willows are an interesting exception. You remember that both kinds of catkin are erect. If you keep a look out when these are ripe you will see that they are **visited by humble bees.** The bees come for nectar which they get at the base of the individual flowers. Observe the nectary (Fig. 19). This is one of the catkins of which you should try to see the several parts. Here the **pollen is sticky;** it is carried from flower to flower adhering to the insects' bodies, and is not distributed by the wind. It will not be difficult for you to see why the catkins are stiff and erect. This gives a firmer foothold for the bees.

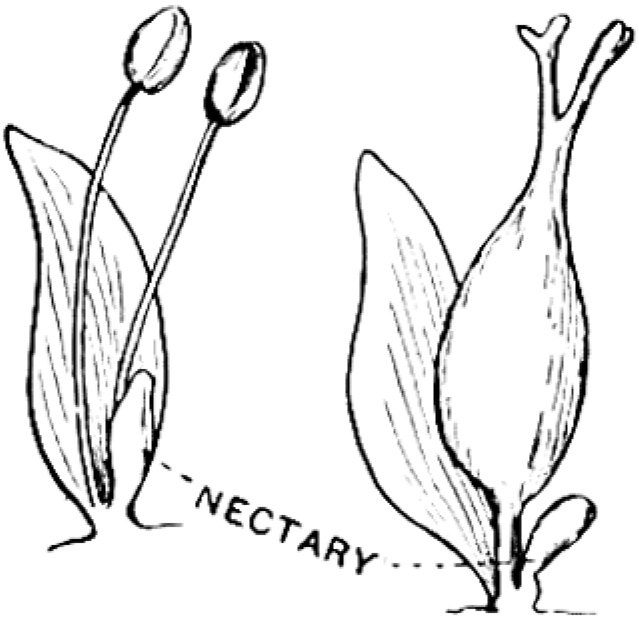

Fig. 19.—Male and Female Flowers of the Willow.

Relation to Leaves.—Have you noticed that in these catkin bearing trees the flowers are very frequently formed and opened before the leaves appear. This is the case in hazel, alder, willow, poplar, and several other trees whose flowers are pollinated by the wind. In the birch the flowers mature about the same time as the leaves appear. Birch leaves are small.

Do you see the advantage of this? In wind pollinated plants it would be a very great disadvantage if the leaves were formed before the flowers, for then much of the pollen would fall upon the leaves and never reach the female flowers at all.

Note some trees whose flowers are not grouped in catkins, *e.g.* elms, ash (Figs. 20-23). Examine the flowers of these with a lens and draw what parts you are able to see clearly.

In another lesson we shall consider the seed which is formed and the way in which it is scattered (p. 264).

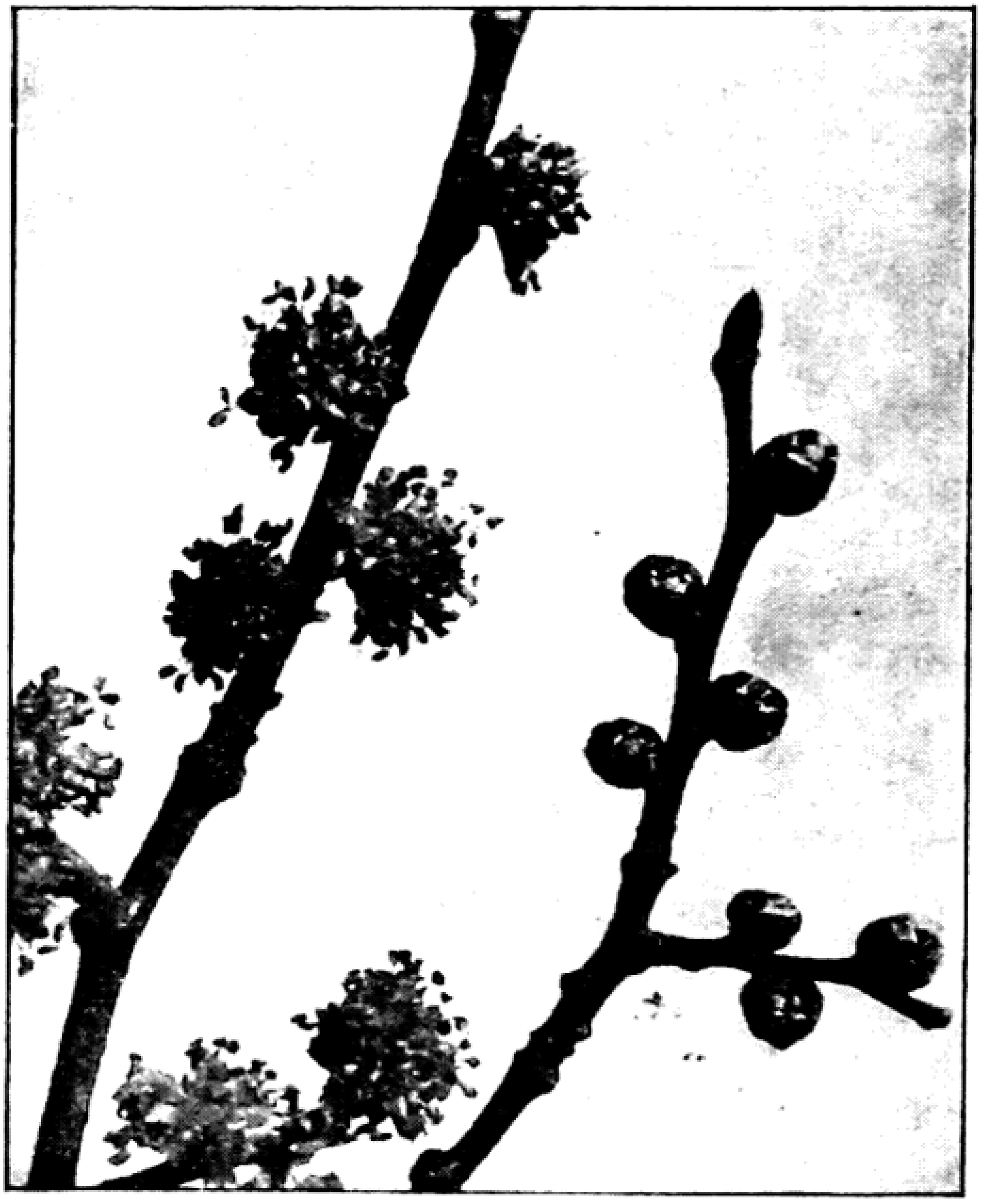

Fig. 20.—Flowers and Flower Buds of Wych Elm.

Meantime there are some things which you should note down with regard to as many trees as you can. Here they are:—

Opposite the name of each tree write down—

(1) the date when its flowers are mature. You will easily recognise this in the male catkins as they then open out, becoming looser, and shed their pollen.

(2) whether both kinds of flower occur upon the same tree, or whether the two kinds are upon separate trees.

(3) whether there are two kinds of flowers or only one.

(4) whether the flowers are mature before the leaves appear.

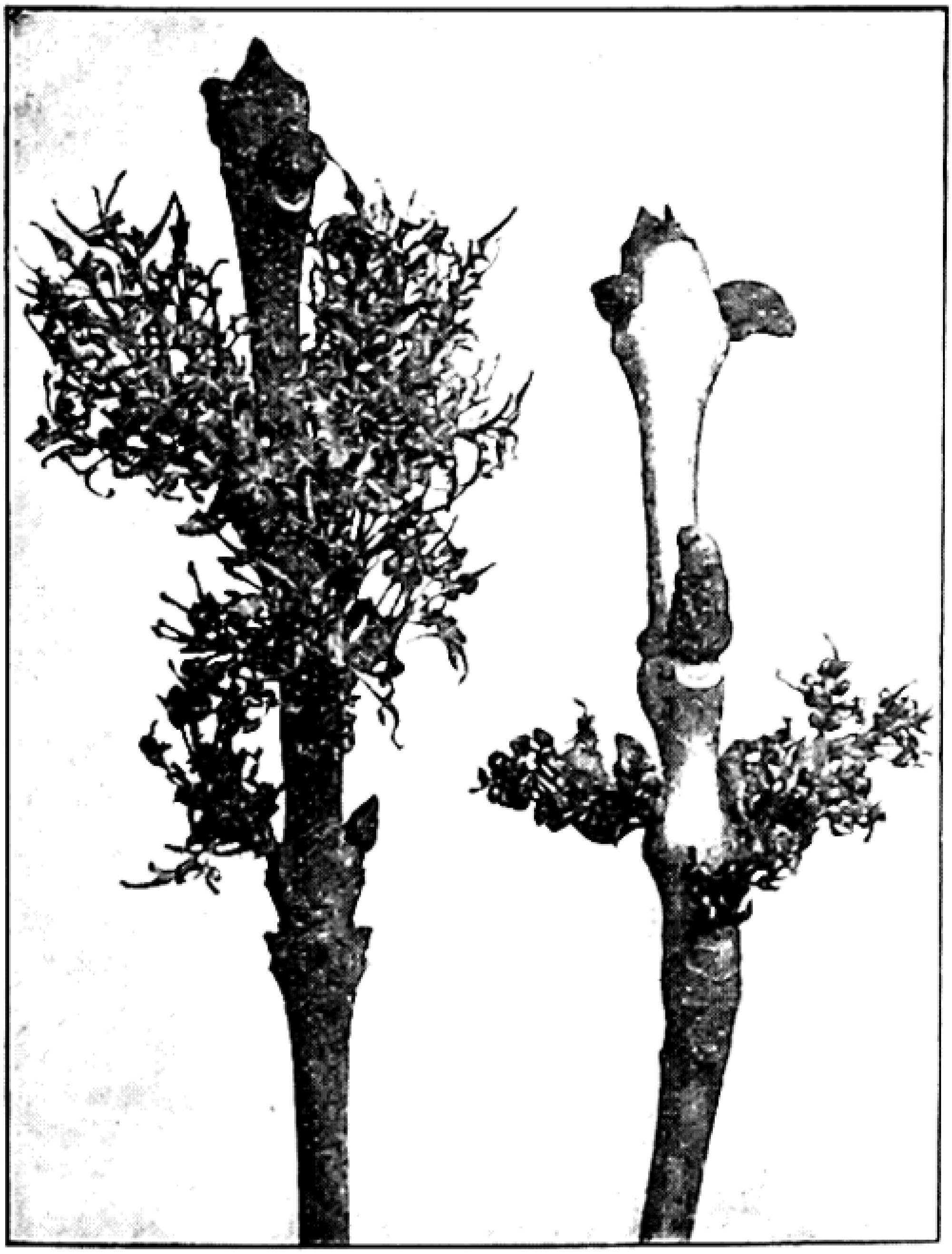

Fig. 21.—Flowers of Ash.

(5) whether the pollen is distributed by the wind or by insects.

(6) whether the flowers are conspicuously coloured or scented, or if they are inconspicuous.

Do you notice the connection between the times of flowering of the inconspicuous type of flower and scarcity of insects at that time, and on the other hand, between the time of flowering of most coloured and scented tree flowers and the greater abundance of insects?

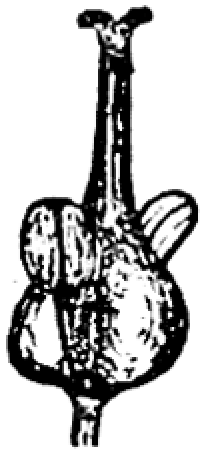

Fig. 22.
Flower of Ash.

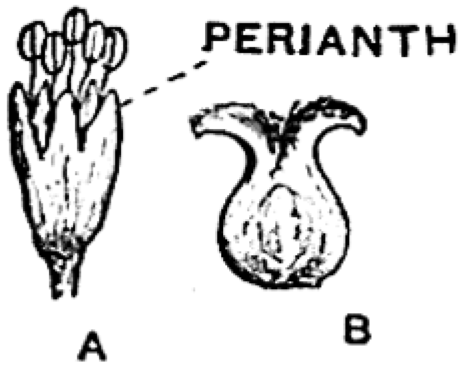

Fig. 23.—Elm.
A, Flower; B, Pistil.

LIST OF THE COMMONER BRITISH TREES

WITH THEIR TIME OF FLOWERING, ETC.

Name.	Time of Flowering.	Note on Flower.	Pollination.
Hazel	Feb. & Mar.	M. & f. on same plant, formed previous autumn, mature before leaves appear	Wind
Alder	Mar. & Apl.	M. & f. on same plant, formed previous autumn, mature before leaves appear	Wind
Willow	Early Apl.	Erect catkins — flowers with nectar, on separate plants	Insect, bees and flies
Wych Elm Common Elm	March	Flowers bisexual—*i.e.* one type only, before leaves appear	Wind
Aspen	March	Flowers m. & f. before leaves appear	Wind
Yew	March	Flowers small on underside of twigs—greenish m. & f. on separate trees	Wind
Black Poplar	Middle Apl.	M. & f. catkins on separate plants, before leaves	Wind
Birch	Middle Apl.	M. & f. catkins on same tree maturing as leaves appear	Wind

Name.	Time of Flowering.	Note on Flower.	Pollination.
Beech	End Apl.	M. & f. flowers on same tree, leaves along with flowers	Wind
Oak	End Apl.	M. & f. flowers; m. flowers in detached clusters in catkins; f. singly, surrounded by overlapping scales	Wind
Ash	End Apl.	Flowers in clusters, complete or m. & f. separate. Both kinds or only one on same tree — before leaves	Wind
Gean	End Apl.	White, ½ in. broad in clusters faintly scented	Insect, visited by hover flies and bees
Wild Service	End Apl.	White, over ½ in., in corymbs	Insect
Dwarf Cherry	Early May	White, nearly ¾ in.—in short stalked umbels; bitter almond odour	Insect, various bees
Sycamore	Early May	Flowers greenish single in drooping racemes, exposed nectar	Insect, bees and flies
Maple	Late May	Flowers greenish single in erect racemes, exposed nectar	Insect, bees and flies
Horse Chestnut	End May	White, in erect panicles, with nectar concealed at base of flowers	Insect, bees and flies
Scots Pine	Early May	Cones. Male forming spike at base of shoot; female cones laterally placed	Wind
Holly	May	Small white flowers in clusters with nectar secreted at base	Bees
Bird Cherry	Middle May	Whitish, strongly fragrant; ½ inch diam., in hanging racemes	Flies, bees, beetles. Self pol. also
Hawthorn	May	White, in corymbs	Visited by carrion loving flies, bees

Name.	Time of Flowering.	Note on Flower.	Pollination.
Hornbeam	May	M. & f. catkins separate, greenish, m. drooping; f. usually terminal	Wind
Rowan	May	Like hawthorn, but duller white	Similar to hawthorn
Laburnum	May	Yellow, in long drooping racemes. Sweet sap in tissue at base of flower which insects bore for	Bees
Spanish Chestnut	May	Greenish; m. & f. on same tree. Pollen flowers, no nectar present	Bees, flies and beetle visit
Lime (common)	End June	Small, yellowish green in clusters attached to middle of surface of a long narrow bract	Bees and flies

LESSON X.

STUDIES OF SEEDS.

[The requisites for this lesson are some broad beans, sunflower seeds, maize, sycamore and ash fruits, and any others. Prior to the lesson pupils should be asked to sow in boxes many different kinds of seeds, to supply these with moisture, and to keep them fairly warm. The germination of the seeds is to be watched, and generally the pupils should be made familiar with the appearance of seedlings, have their attention drawn to the enormous numbers of seeds which are scattered in the soil, and with the resulting competition for place and light which ensues when these germinate. Such facts can well be illustrated in the seed boxes in school, in a neglected garden or by the wayside. See lesson p. 254].

General Considerations.—The more we study flowers and their structure there grows upon us a feeling of the great importance of seeds. A study of the leaves, stem, roots, and other parts outside the flower shows us these parts working together for the making and protecting of the individual plant. The flower, on the other hand, we discover exists not for its own sake, but for the production of seed. We notice further that it is not simply seed in kind but also in quantity that each flower strives to produce. Think over this carefully.

Many flowers die when their seed is produced and scattered, (annuals and biennials) many others, although they do not actually die, wither down to the ground after producing their seed (herbaceous perennials). These things show us that when the seed is produced the work of the plant for the year at all events is finished.

Germination.—What then is the seed? You have been planting seeds in soil, giving them water, air and warmth, and out of them you have seen arise into the air the beginnings of new plants. This process is called **germination.**

There is no question but that these plants actually came out of the seeds. Have you proved that? Yes, you have grown the little plants without soil—with moisture, air, and warmth simply. We shall now see how much is actually in a seed before it grows at all.

Competition amongst Seedlings.—Have you seen in your seed boxes how some seeds germinate sooner than others? Also have you noted that some of the young plants grow faster than others? These differences are often of great importance, for in nature there is a real struggle for room, and those seeds which germinate quickest or the young plants that can grow fastest, often by taking room and light prevent others from growing at all.

The Broad Bean Seed.—Now let us examine a broad bean which has been soaked in water overnight. It is of course, a seed (Fig. 24). Upon the outside there is a tough whitish skin. This is called the **testa** or seed coat. Notice on the edge, a rather long blackish scar. This is called the **hilum.** What is the hilum? This is the place where the seed was attached to a short stalk within the pod in which it grew. If you press the seed which has been soaked in water you will find that a drop flows from near one end of the hilum. There is a small opening there known as the **micropyle** or little gate.

Now remove the testa and observe lying at one end of the seed within, a short bluntly pointed body—this is the root of the seed plant. This root is called the **radicle** and the seed plant is known as an **embryo.** The great mass of this embryo plant consists of the two flattened rounded parts, which in the soaked seed are easily separated from each other. These are known as **cotyledons** or seed leaves. In this case they are not easily recognised as leaves because they are stocked with food. What is the use of this food? It is to build into the young plant at germination—to lengthen the root and other parts so that they may come into contact with soil and air and begin to grow.

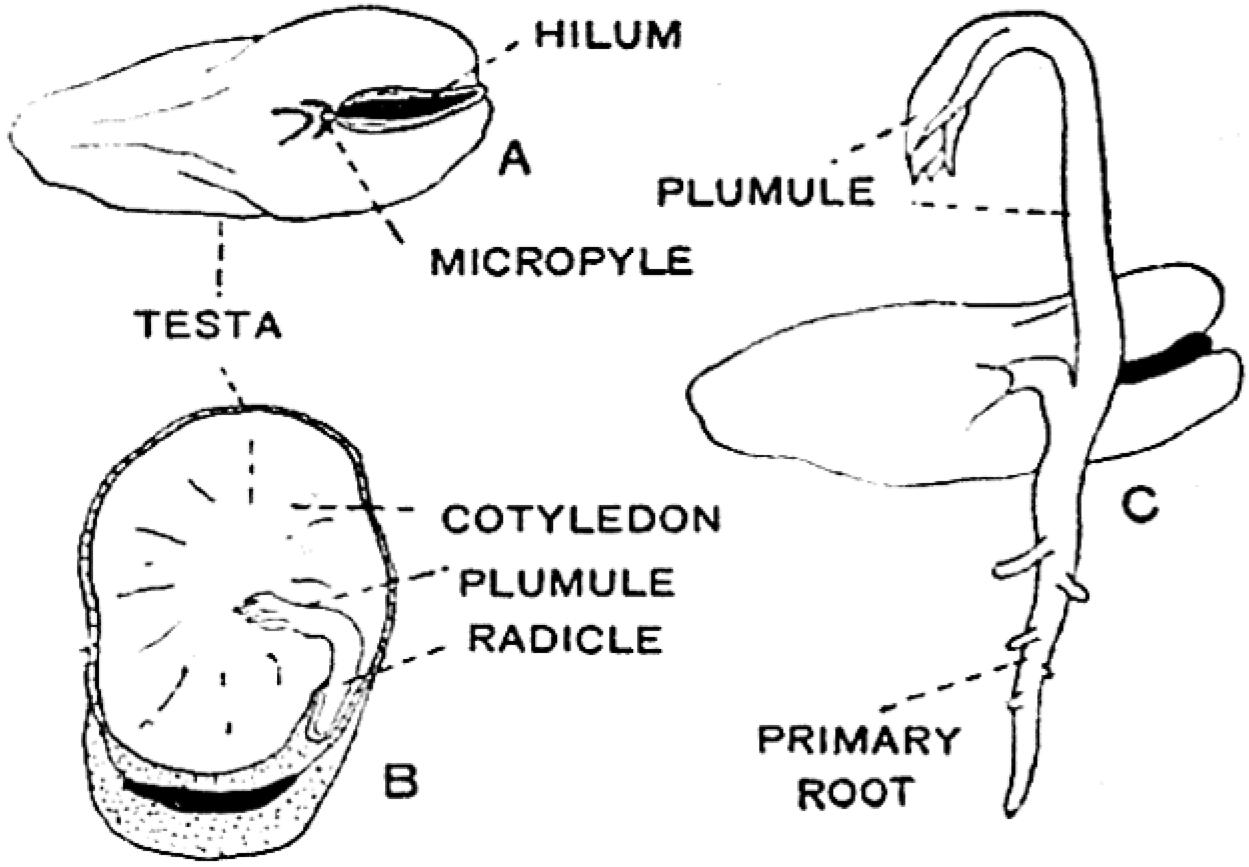

Fig. 24.—Seed and Embryo of Broad Bean.
A, entire; B, one cotyledon removed; C, after germination.

Gently separate the cotyledons from each other. One will break away from the other, leaving the young plant exposed between. Notice that continuing from the radicle and directed away from it there is a short part bent inward from the margin, This part is termed the **plumule.** It is the shoot or stem of the embryo. Around its tip you may manage to see the beginnings of young leaves. When the bean germinates the cotyledons remain below the ground.

Make a series of drawings in the course of your examination to show all the foregoing.

Sycamore Seed.—Now take a fruit of the sycamore which has also been soaked in water for a time and separate the two halves which each contain a seed. Remove the wall of the fruit with the seed coat from around the seed (Fig. 25). Observe the soft hairy covering of the cavity. Remove the brown seed coat (testa). Identify the radicle, plumule, and two cotyledons. These last are green, long and strap-like.

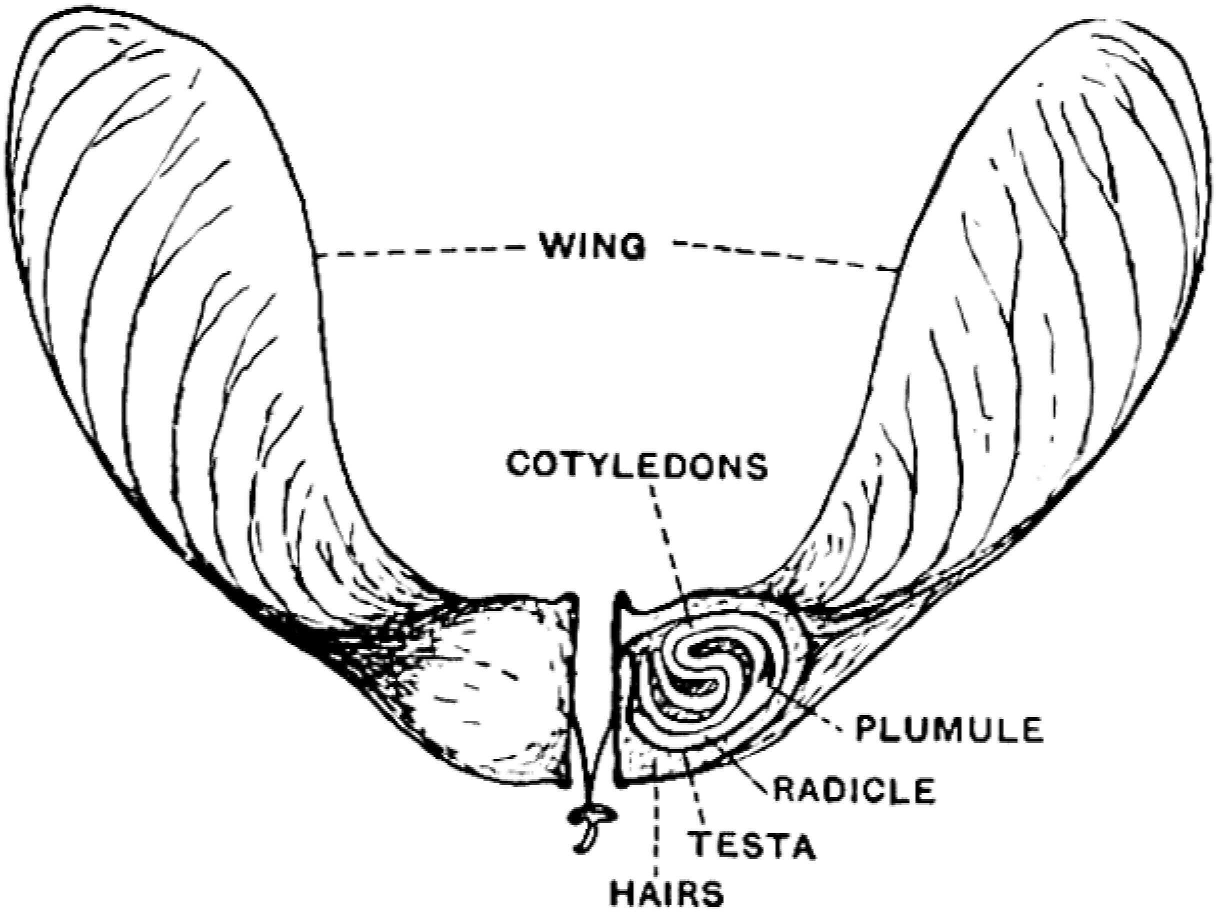

Fig. 25.—Fruit of Sycamore, with wall cut away on the right side to show seed and embryo.

No separate food store can be recognised. The cotyledons contain it. Observe how neatly they are coiled. Uncoil them and contrast their great length with the small space in which they lay. Did you plant any sycamore fruits? Have they germinated? When they germinate, do the cotyledons come above the ground? Draw a sycamore embryo plant. Look for such out of doors in the neighbourhood of the trees if you have not had an opportunity of growing any.

Seed of the Ash.—The ash is a smaller seed but it will repay you to examine it also. Soak the fruit and remove the seed which you will find attached by a long strand to the bottom of the cavity (Fig. 26). Split the seed lengthwise, parallel to its flat surfaces and you will find a **small but quite distinct embryo plant** with two minute leaves, radicle and plumule. Do not be satisfied until you have been able to find this. In this case the food store (the large white masses surrounding the embryo) you see is outside the plant. Before the seed germinates, which is in the second year after it is formed, the food store is absorbed by the cotyledons. When the ash germinates, these cotyledons come above ground.

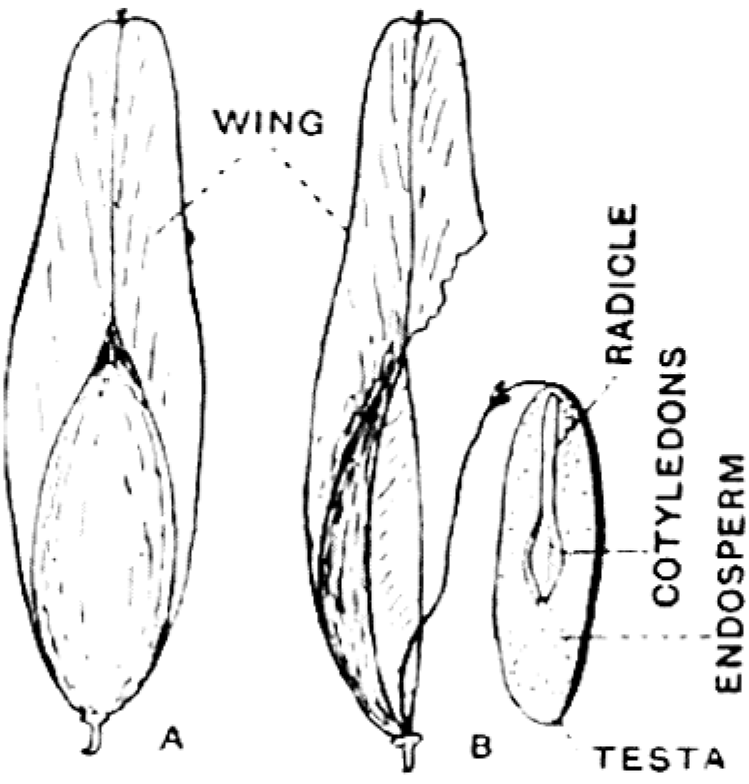

Fig 26.—Fruit and Seed of Ash.
A, entire; B, seed removed and opened to show young plant.

Draw all that you have seen of the ash seed and its contents.

These are three common examples illustrating the chief characters of a seed. Although they differ in some respects, *e.g.* in the place in which reserve food is stored, in the quantity of it, in their time of germinating, and in the behaviour of the cotyledons at germination, **they have all an embryo plant within.** This is the important thing about a seed.

Revise all the parts and state the chief use of each. Grow beans in clean water, changing the water regularly noting how far they may grow before the reserve foods are exhausted. Line a tumbler or glass chimney with clean blotting paper, placing the soaked beans between it and the glass. Fill up the glass with clean moss and keep moist (Fig. 27). The beans may be kept in the dark for a time; remove to the light when the first leaves unfold (Fig. 24). Make a series of drawings of successive stages, noting the dates at which they appeared.

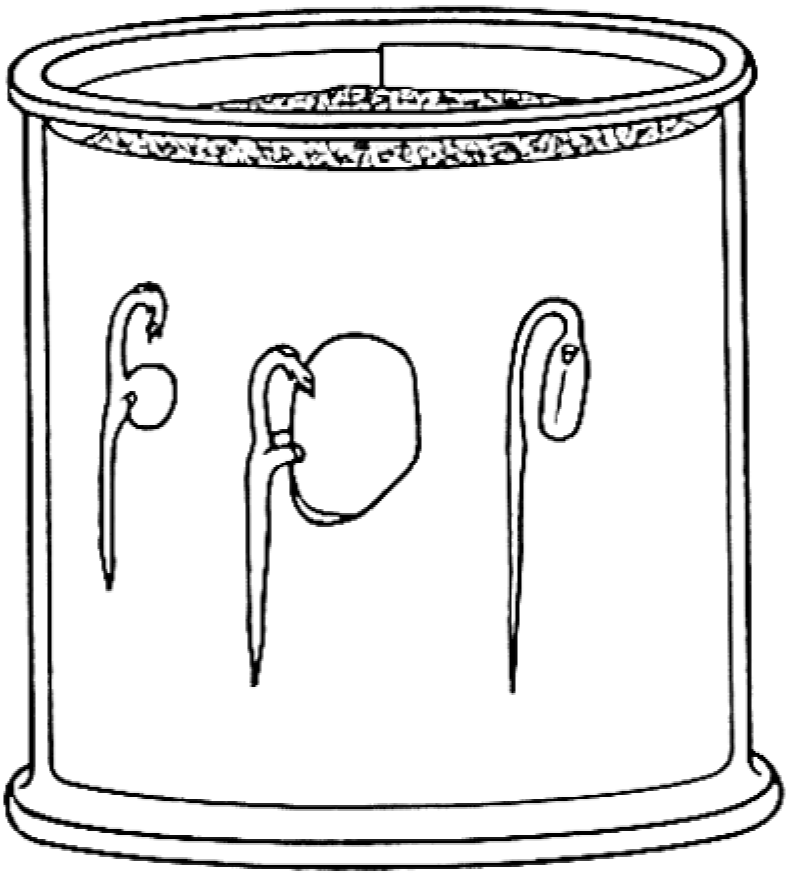

Fig. 27.—Germination Jar.

OUTDOOR AND PRACTICAL STUDIES.

SPRING FLOWERS, TREES, FERNS, ETC.

[These exercises are given as suggestions for the cultivation of out-door observations on the part of pupils. They should be begun as early in the season as possible. Notes taken by the pupils should be examined weekly and discussed.]

At this season of the year when wayside, field, and wood begin to brighten with the colour and freshness of the spring flowers and their foliage you must watch their appearing, noting the times of their coming, learning names, and observing haunts.

Flowers.—This is the best time to make a new beginning in the study of flowers, because their numbers are not too great; you must try and keep pace with them as long as you can, finding out their names and noting when and where they are to be found. Those you have seen in former years will be specially welcome, for we welcome each fresh appearance, and the unknown ones will invite us to discover what they are.

We have been studying some in school, but there are many which at present we shall have to be content with knowing in a less detailed way. Here are some other flowers which you are to look for, and, having found, bring to school during the months of spring :—

Coltsfoot.
Butterbur.
Marsh Marigold.
Golden Saxifrage.
Lesser Periwinkle.
Greater Stitchwort.
Red Campion.
Hairy Bitter Cress.
Dog's Mercury.

You need not confine yourselves to these, for there are many others you will come across if you are on the look-out. Learn the names of as many new ones as you can and revise your knowledge of the old. Write down in your note-book as many as you find, giving place, date, and kind of situation.

Trees.—Besides wild flowers out of doors there are many interesting things to note upon the trees in spring. In town you can study these in the parks. At another time you shall study in school the flowers of trees (p. 39). Meantime here are some things for you to note upon such trees as are in your neighbourhood.

Tree Buds.—Note the appearance of the buds in a set of trees. Keep watching these on a few selected trees of different kinds. Examine at short intervals. Obtain a few twigs and place these in water indoors. Keep moderately warm. Both on these and on trees note the **swelling of the buds**, the **fall of the protecting scales**, and the **unfolding of the leaves.** Attempt drawings of a series of stages (Fig. 28).

Write down the colours, size, arrangement, and general appearance, whether smooth, sticky, hairy, etc., of the buds you examine.

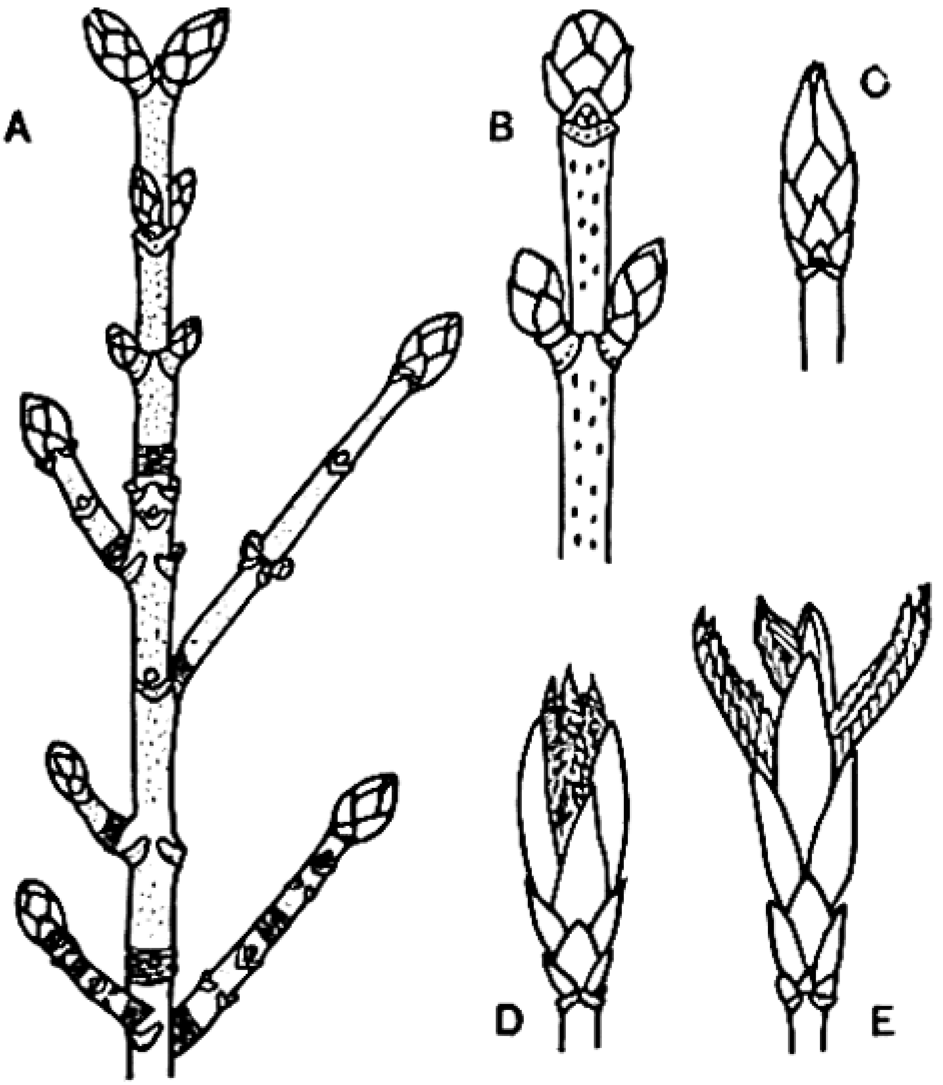

Fig. 28.—Twig of Sycamore. B to E, stages in opening of bud.

The Young Leaf.—Examine these, notice their delicate texture and colours, folding, or other features. Record the dates upon which the buds were definitely opened in the case of each tree noted.

As an exercise, draw a leaf of the horse-chestnut, at the stage which shows the backward folding of the leaflets (Fig. 29).

Flowers of Trees.—Keep a look-out for these appearing, note dates, etc. (A separate lesson on these is given, p. 39). Collect young cones of conifers, *e.g.* larch, Scots pine. Identify the parts of these (p. 364).

Plant in school garden or in pots any tree fruits you have previously collected.

Seedlings.—Search in woods or other likely places for tree seedlings. Examine and draw one or two common ones, *e.g.* sycamore or ash.

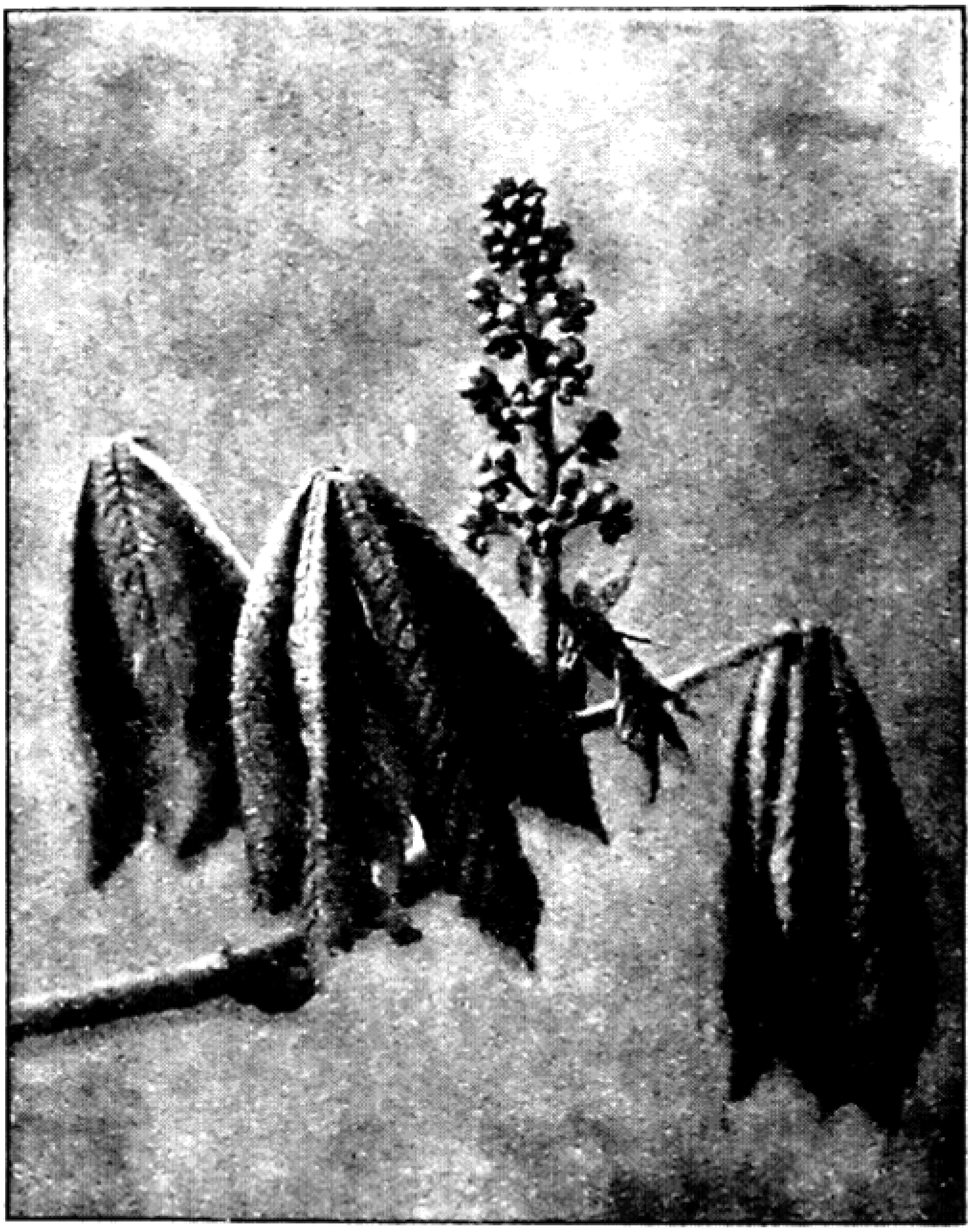

Fig. 20.—Twig of Horse Chestnut in Spring.

Ferns.—Take some spore-bearing fronds which have been kept in paper from the previous autumn, and shake the spores on to some fine leaf mould placed in water in an open dish, or on to pieces of tile or brick over which boiling water has been previously poured to kill adherent germs. Keep moist, but do not water directly in case of washing away the spores which are very minute. Keep in a moderately warm place in a dull light. Watch the appearance of the small green heart-shaped bodies (prothalli) from which ferns may later develop (see p. 280).

GENERAL CHARACTERS OF THE NATURAL ORDERS

of the Flowering Plants (other than Trees) in the foregoing Chapter.

(For explanation of Botanical Terms see Glossary (p. 465), and for suitable Botanical Text-Books in which fuller information, etc., will be found see p. xv).

Ranunculaceae.

The parts of the flower—sepals, petals, stamens, carpels, are all free; *i.e.* there is no cohesion (union of like parts) nor adhesion (union of unlike parts). The number of stamens is always large (indefinite). Fruit usually achenes or follicles. In a number of flowers the sepals resemble petals.

Ranunculus ficaria—**Lesser Celandine.**
Anemone nemorosa—**Wood Anemone.**
Caltha palustris—**Marsh Marigold.**

Cruciferae.

Sepals four, free, in two pairs; petals four, crosswise; stamens six; two short outer, and lateral opposite saccate sepals, four inner, longer. Nectaries on head of flower stalk at the bases of the short stamens. Ovary of two united carpels, superior and bilocular in fruit, owing to the growth of a secondary partition.

Plants mostly herbs with alternate and exstipulate leaves—

Cheiranthus cheiri—**Wallflower.**
Capsella bursa pastoris—**Shepherd's Purse.**

Violaceae.

Flower zygomorphic (bilateral) in European species. Sepals five, free; petals five, free—anterior one, with a spur; stamens five, pistil of three coherent carpels; ovary single-chambered, fruit a capsule splitting explosively into three parts.

Herbs with alternate stipulate leaves—

Viola odorata—**Sweet Violet.**
Viola canina—**Dog Violet.**
Viola tricolor—**Pansy or Heart's Ease.**
Viola palustris—**Marsh Violet.**

Primulaceae.

Sepals five (or four), united; petals five, united; stamens five, epipetalous (springing from petals); pistil of five united carpels with single style. Ovary single-chambered. Fruit capsular.

Herbs with simple exstipulate leaves—

Primula vulgaris—**The Primrose.**

The following are members of this Order:—

Primula veris—**Cowslip.**
Lysimachia vulgaris—**Yellow Loosestrife.**
Anagallis arvensis—**Scarlet Pimpernel.**

Ericaceae.

Sepals, free; petals, united; stamens usually double the number of petals or sepals; anthers opening by pores or slits and often with horn-like appendages (e.g. *Erica*). Pollen grains frequently in tetrads; pistil four or five coherent carpels with a corresponding number of chambers.

Evergreen, shrubby plants—

Rhododendron, sp. **Rhododendron** or *Alpine Rose.*

Other members of this Order are:—

Erica tetralix—**Cross-leaved Heath.**

Calluna vulgaris—**Ling or Heather.**

Vaccinium species are **Blae-berry, Cowberry** and **Cranberry.**

Liliaceae.

Perianth of six segments; six stamens; ovary superior, of three united carpels, with three chambers.

Herbaceous plants with bulbs or rhizomes—

Convallaria majalis—**Lily-of-the-Valley.**

Other members of this order are:—

Scilla nutans—**Bluebell** or **Wild Hyacinth.**

Lilium martagon—**Turk's Cap Lily.**

Amaryllidaceae.

Perianth of six petaloid segments; stamens six; pistil of three united carpels; ovary inferior.

Bulb forming herbs mostly—

Narcissus pseudo narcissus—**Daffodil.**

Narcissus poeticus—**Poet's Narcissus.**

Galanthus nivalis—**Snowdrop.**

The teacher who is a beginner should verify the foregoing points on as many as possible of the plants named.

QUESTIONS ON CHAPTER I.

(Spring: Plant Studies.)

1. To what group of common plants does the lesser celandine belong? Name two other plants of the same type.

2. Describe the leaf of the lesser celandine. What is the use of the "root tubers" upon this plant?

3. In what part are the food reserves of the wood anemone stored?

4. To what feature does the "wood anemone" owe its name?

5. What is a bract?

6. What name is given to the six yellow petal-like parts of the daffodil? What is the large trumpet-like part called? Name another flower which has a similar, though smaller structure.

7. What is meant by the following:—"Daffodils, which come before the swallow dares and take the winds of March with beauty"? Who wrote this?

8. What notable difference is there in the general shape of a narcissus and a pansy? How many petals has a pansy? Where is its spur? What do you find within it?

9. In what kind of situation have you found the lesser celandine growing?

10. What is the meaning of the term Cruciferae? Name a plant belonging to this Order.

11. What attractions does the wallflower have for insects; where is its nectary situated?

12. Who wrote "A primrose by a river's brim a yellow primrose was to him, and nothing more"? What does this mean?

13. How many kinds of primrose flowers are there? Describe them. Can you say in a general way what is the advantage to the flower in existing in more than one form?

14. Describe a leaf of a rhododendron.

15. Name six trees whose flowers are pollinated by the agency of the wind.

16. Name three trees whose flowers are formed before the leaves appear. What is the advantage of this?

17. The male catkins of the willow are erect, those of the poplar are drooping. Can you tell me the meaning of this difference?

18. Name twenty flowers which blossom in the spring.

19. What is a seed? Name the parts of a young plant present in a seed.

20. Name two differences between the seed of a bean and the seed of a sycamore tree.

21. State generally what are the uses of sepals, petals, stamens, carpels.

22. To what structures do the following names apply:—stamen, filament, anther, carpel, pistil, style, stigma, ovary?

23. What is a "perennial" plant? Name one.

24. What is chlorophyll?

25. What is the meaning of flowers being brightly coloured, sweetly scented, and producing nectar?

26. What arrangement exists in the wallflower for preventing unsuitable insects from reaching the nectar?

27. Write an account of the way in which a pansy is pollinated by bees.

28.* Name some flowers which show radial symmetry and some which show bilateral. State any advantage of the latter form.

29. What are "honey guides"? Name a plant which shows them clearly.

30. What is a "pollen box"? Name a plant which shows one and state the uses of it.

31. In what does pollination consist? What does it bring about?

32. What is self-pollination; in what way is it inferior to cross-pollination?

33. By what means is the lily-of-the-valley plant distributed.

34. Explain the terms: perianth, inferior ovary, inflorescence.

35. What is a catkin?

36. Write a short account of the general uses of leaves and roots.

CHAPTER II.

ANIMAL STUDIES IN SPRING.

LESSON XI.

THE EGGS OF FROG AND TOAD.

[For this study spawn should be collected in the early spring as soon as it appears. In the country scholars usually know the likely places and no difficulty is experienced in securing a supply. Endeavour to obtain a quantity of both frogs' and toads' eggs. It is well also for the teacher to preserve some in formalin or alcohol for use when living spawn cannot be found (see p. 466). If the adults are collected before spawning they may be kept for a short time in a cool vessel containing a little water. Spawn may be secured in this way, although there is a possibility that it may not develop.

Keep the spawn in a moderate supply of water in an open vessel in a fairly warm place in a good light. Place some healthy water weed in the same vessel.

Assuming the spawn has been secured quite early, a lesson on the following lines may be taught.]

General Appearance of Spawn.—Here is something which appears each spring in marshy places and reedy ponds. Its appearance is one of the events of the month of March. (The date first noticed should be recorded each year in the school nature calendar.)

You will observe this substance is of two kinds. How do you describe the appearance of each? Both consist of a **clear jelly-like** substance in which lie many small **black-looking balls or spheres.** In one case the jelly consists also of spheres, and these are not grouped regularly but lie together in a **heap or mass.** In the other the jelly consists of a **cord or strand** in which the dark balls are embedded (Figs. 30 and 31).

Now if you have been fortunate enough to obtain spawn quite soon after it has been shed and have examined it at once, you will have seen that in the first case the jelly round each separate sphere is firm and small in amount. The jelly sphere is not much larger than the dark one within (Fig. 32). In the other case the cord of jelly is slender and the enclosed spheres lie in a single row within it. But as in both cases the jelly swells up rapidly you may have missed this stage. If so, remember to look out for it next year. I am sure you know already that the two kinds of spawn belong to two different though very similar animals, viz. the frog and the toad. You also

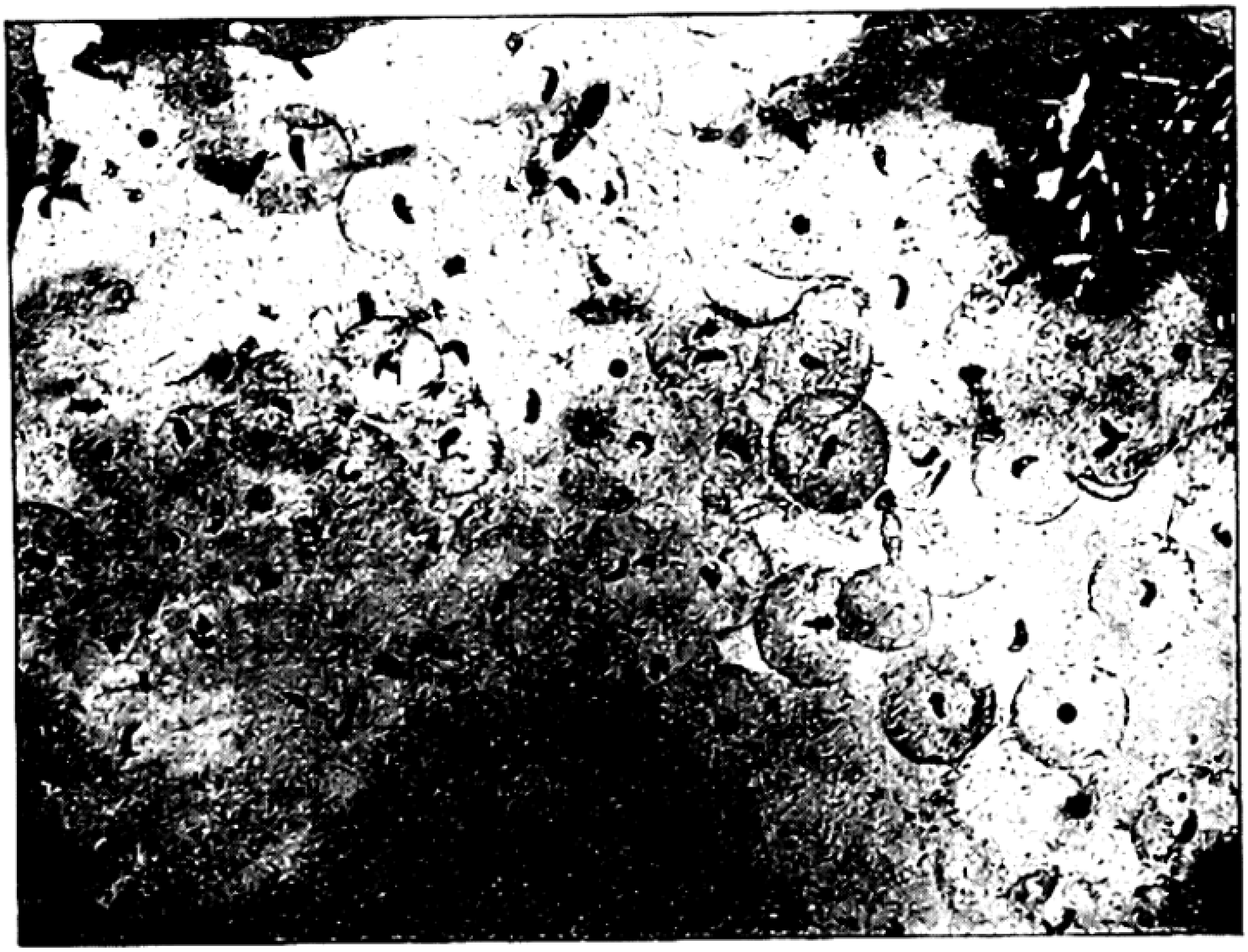

Fig. 30.—Spawn of Frog, with Tadpoles partially developed.

know, I think, what the spawn really is. These masses of jelly-like stuff are really **eggs,** and from these you have doubtless watched the **gradual growth of tadpoles,** which are the young of frogs and toads.

The Parts of the Spawn.—Now I would like to ask you some questions, and you will be the better able to answer them if you remember three things, viz. the **spawn**

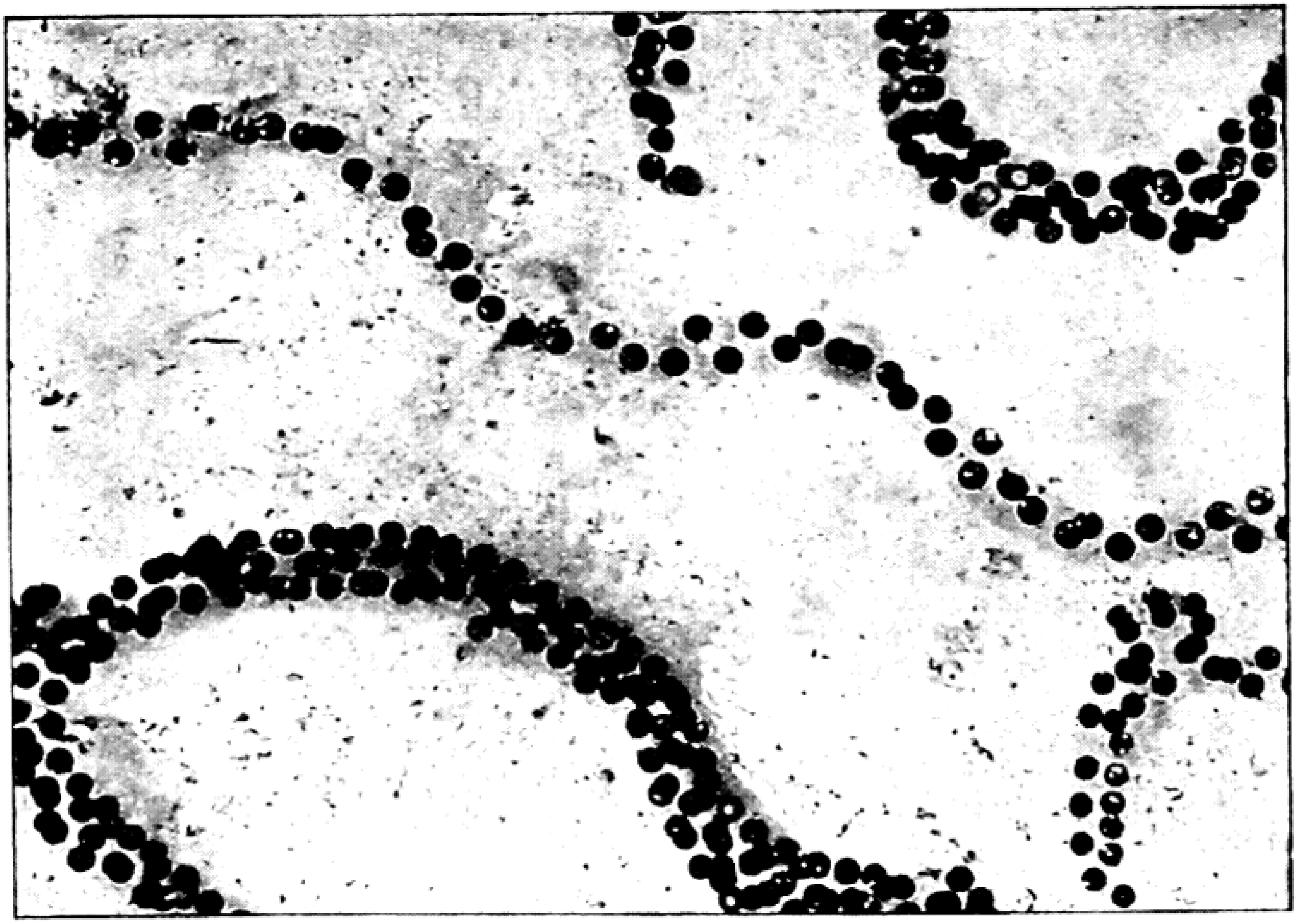

Fig. 31.—Spawn of Toad.

is alive, it lives in **shallow water,** and the time of the year it appears is the **month of March.** Let us now for a little look more particularly at the frog's spawn. We have already noticed that in each case there are two distinct parts, the jelly and the contained denser sphere. What do we call the dark enclosed body? This is the **egg proper.** For clearness sake let us **draw a single sphere** of a frog with its enclosing jelly.

Let us next name the parts—jelly outside, egg proper within. Why do we say "egg proper"? The best answer to that is got when we watch the growth of the egg. If you have done so, what have you noticed? Have you not seen that the tadpole arises from the "egg proper" and is **not formed by the jelly at all?** So that the jelly is after all something outside the egg. Now the egg is the more important thing, of course, and we shall ask some questions about it; but first of all let us see if we can discover why the eggs are enclosed in jelly, since the jelly does not go to the making of the frog.

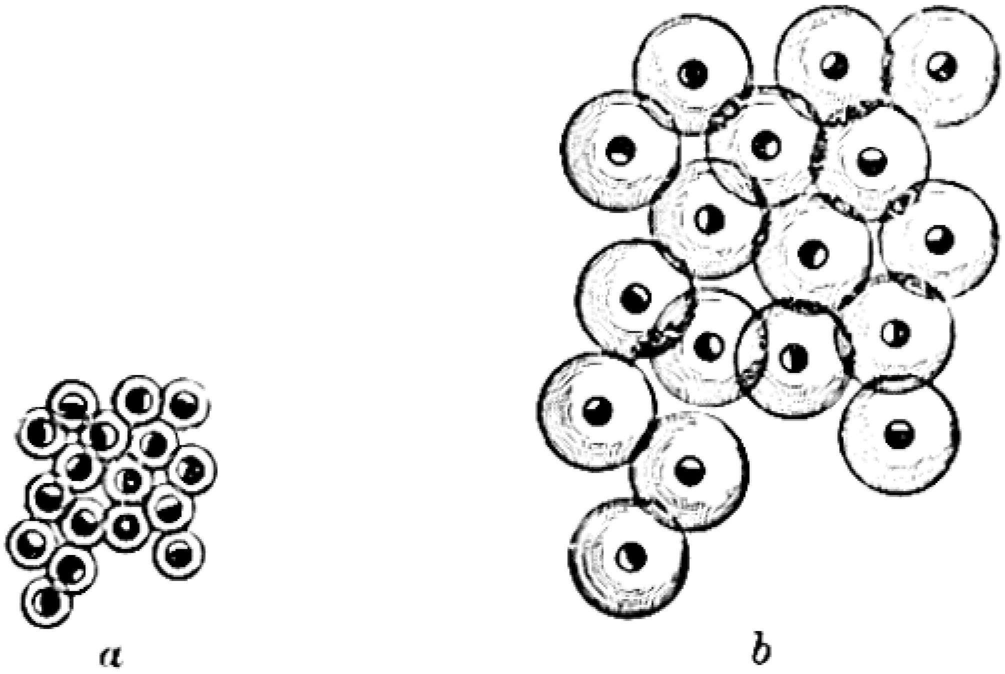

Fig. 32.—Spawn of Frog; *a*, newly shed; *b*, some hours afterwards.

Uses of the Jelly.—Have you not at one time or another tried to handle or carry frog's spawn? It is not easily lifted or held, it is so **slippery.** What is the advantage in this slipperiness? Does it not serve to **protect the eggs from being eaten** by other animals, *e.g.* birds? They cannot hold it in their bills, unless these are broad and flat as in the cases of ducks. Remember that even frogs' eggs are good for food and many birds would eat them if they could.

Remember, too, that the eggs are usually laid in shallow water—in marshy places—and there is always a risk that the **eggs may get dried up.** The strong March winds often dry up the pools, and if the eggs get dried they die. How does the jelly prevent this? You remember that the jelly swells up rapidly after it is shed by the frogs. In doing so it is taking up water, and as it keeps this water a long time, there is no doubt it is often **useful in keeping the eggs moist** when otherwise they would dry and die. The water, too, is needed to **hold the oxygen** which the egg requires for breathing. You may be surprised to learn that eggs breathe, but you need not be so when you recall that all living things do so, plants and animals alike, and these eggs are alive.

In another way the jelly helps the eggs to breathe. In the spaces between the globes or spheres very **small green plants (Algae) often get enclosed** and they are thus kept near the eggs. You know that when green plants are exposed to sunlight they give off oxygen, the gas which the eggs require for breathing. So you see again how the presence of the jelly may be of advantage to the eggs.

Then we know that it is often very cold in March. Perhaps you are feeling that at present. The sun does not rise very high in the sky, its rays are very slanting and heat is rather scarce. But frogs' eggs, like most eggs, grow into young animals all the faster if they get some heat—not too much, but just the right amount. It is on the whole an **advantage to the eggs to grow rapidly** at first, that is as long as they are helpless and cannot take care of themselves. As a rule both animals and plants which can grow rapidly in the early stages have a better chance of growing up. Infancy is a risky period in life. Can you think how the jelly helps in this? These globes of jelly **gather the rays of the sun,** bending them inward towards the eggs lying at their centre, thus helping growth by adding a little heat when heat is rather scarce. Then no doubt, too, the jelly acts as a a **kind of blanket,** keeping a more even temperature about the eggs and protecting from frost.

Lastly, here we may note the interesting fact that the jelly has **preserving** (**antiseptic**) **properties.** No doubt this is useful in various ways.

For example, in a mass of spawn from one cause or another—weakness, and so on—a certain number die. But owing to the presence of the jelly decay progresses very slowly, and were this not the case the living eggs would suffer in health and perhaps die also from being so near to the dead ones.

Do we not see therefore how important this jelly is—how **it increases the chances of life** in a number of ways—although, as we have already noticed, it does not take any direct part in the building up of the frog's body.

Before leaving this subject let us write down shortly the chief uses of this jelly.

Relation to		
Enemies	(*a*)	It protects from interference of animals.
Water	(*b*)	It prevents drying.
Oxygen	(*c*)	It helps breathing.
Heat	(*d*)	It supplies warmth.
Disease	(*e*)	It prevents infection.

The Egg.—Now let us look at the egg proper. When the egg is quite young we can see clearly that it **consists of two parts.** There is a black portion which extends over at least one half of the surface, and a white portion which very soon gets covered over. Very commonly this white end is covered over before we find the spawn. The black end is called the **animal end,** because here most of the **living substance** lies; the white end is termed the **yolk end,** because it consists mainly of **food substances.**

Can you think why there is a food supply in the frog's egg? The answer is that here, as is many other eggs such as those of fish and birds, food is needed to build up those parts of the body which must be made before the animal is able to go in search of food for itself. As we watch the frog's or toad's eggs we see them gradually change form until the tadpole can be recognised. We shall follow these changes in another lesson.

LESSON XII.

THE LIFE HISTORY OF THE FROG.

[*First Lesson.*—The spawn collected for the purpose of the previous lesson should be kept in a suitable place and the development of the frog or toad followed through its various stages. Quite suggestive and profitable experiments of a simple character may be devised which will show the effect of different conditions on the growth of the tadpoles. For example, the eggs may be divided into two equal lots, and these placed under different external conditions of exposure, light, temperature or food supplies and the results in rate of progress recorded. The dates of the appearance of the stages recorded below should be noted.

The most favourable conditions for the growth of the tadpoles in the early stages are those suggested for the keeping of the spawn (see previous lesson). As the tadpoles begin to assume definite shape, the amount of water weed should be increased; generally speaking, if natural water from the pond or marsh is used to start with, the addition of food will not be necessary for some time. Decaying weeds should be removed and replaced by healthy, but it is neither necessary nor desirable to change the water, unless exceptional circumstances arise.

Perhaps the best results will be got from the study by allowing the vessels containing the tadpoles to stand in the schoolroom where the pupils can see them and observe their behaviour at will. Let the pupils watch them swimming and feeding and generally observe the "incidents" of this little sphere of activity. Then as definite structural changes appear in the tadpoles themselves short studies of these should be made, the pupils should be asked to draw these until a complete set is obtained representative of the various stages passed through in this fascinating and suggestive life-history.

For the convenience of the teacher the important stages which can be recognised with the naked eye are given below with suitable lesson suggestions.

Stages I. and II. may well be taken together as one lesson.]

STAGE I.

Signs of Life.—We have kept the spawn for a week or two and during that time we have been discovering signs that the eggs we collected and preserved with care are really living. What signs have we noted within the past few days? Write down all that you have observed. First a gradual **change of shape.** The **change in colour** may be said to take place in the egg stage, but now that a change of form is evident we shall term this the **first stage** of the tadpole.

Let us now remove some of these very young tadpoles from the large vessel and examine them closely with a pocket lens in a small open vessel. Quite likely those of you with sharp eyes will be able to see as much with the naked eye as I can with a lens. I can make out the head and body in all, and in some which have grown a little faster than the rest a very short, flat and thin tapering tail in addition. In the younger ones no movement occurs, but in those slightly further grown slow curling movements of the tail making the body form a comma shape are to be seen. When we see these movements commence we are really observing the beginning of the next stage. Stage I. is a passive stage. That is, there is **no movement.**

The tadpole **does not feed** and yet we may actually watch it **grow in length** and **change in form.** If it is not feeding, how is it able to grow? It will help you to answer this question if you remember that in the egg the living substance from the black end grew and covered over the white yolk. The **yolk** was not destroyed or used up, it was merely **hidden within,** and it is now being used to make various parts, particularly the **tail,** which will be **needed very soon** to enable the creature to go in search of food. Then since the tadpole has not begun to feed it does not need a mouth yet and so we find it **mouthless.**

If you look closely at the larger of the tadpoles at this stage, you will see they have **knobby-like growths** at the sides of the neck. These knobs become gills, but as yet they are unformed and the tadpole still **breathes by the surface** of the body as the egg does.

Lastly notice that the **jelly still surrounds** the eggs as an entire sphere or ball (Fig. 30). It is getting very loose and will soon become so watery that the tadpole is able by means of its newly made tail to wriggle clear of it altogether.

Stage I. may be summed up as a stage in which certain **signs of life appear.** These are *change of shape and size.* There is *no feeding* and *breathing goes on by the surface of the body only.*

STAGE II.

Movement and Feeding commences.—We have already noticed that the first stage is soon passed through. In the course of a day or two after it is definitely reached, the tadpoles are seen to have altered in several respects. Let us look at them. What change do you notice?

(*a*) They have grown longer and more slender. In what exactly does the change consist? A **distinct tail** is now present, and we can see tadpoles showing various stages from a quite small one to one which is well formed and long.

(*b*) From near the hind border of the head small knobby-like outgrowths may be seen which give the head a rather triangular appearance when looked at from above. During this stage these knob-like growths increase to thread-like tufts in which the blood circulates. These are called **"external gills,"** and they now form the important breathing organs (Fig. 33).

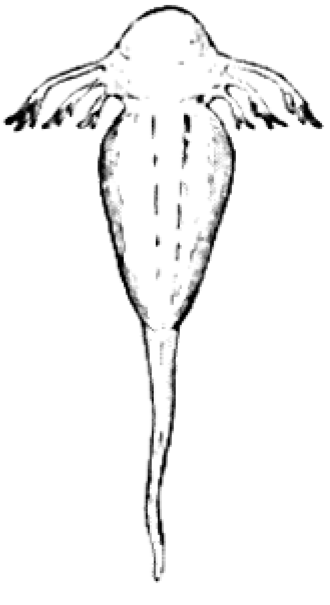

Fig. 33. — Tadpole with external gills.

(*c*) During this stage **movement begins.** What kind of movement do you see? First, a very slow doubling of the body into a comma-like shape. Later S-shaped curves are also slowly formed and unformed. It is interesting to watch the tadpole **trying its new-found powers.** Soon the movements become frequent and quicker. The tadpole becomes fairly active; it may be seen wriggling itself free from the jelly and fixing itself by the under side of the head to weeds or to the side of the vessel. During the latter part of this stage also a **mouth is formed,** and gradually the body becomes rounded, taking the proper tadpole shape. By and by the gill tufts upon the neck disappear, and by this time the tadpole is quite active, swimming freely in the water and feeding (Fig. 34).

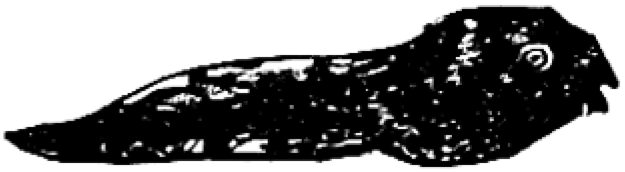

Fig. 34.—Tadpole with internal gills.

The passing away of the gills from the outside of the body marks the close of the second stage. You must be sure that you **see every one of these things.** Write out for this stage all that you have seen which belongs to it. Here it is:

Continued growth in size bringing a *change of shape.*

The power of movement—*a tail being formed.*

Outer gills to breathe by.

A *mouth is formed* and *feeding commences.*

It may be possible in some cases to show that the gills pass out of view on the right side of the body before the left. They are really in the first instance covered over by a fold of skin which leaves an opening on the left side.

These changes raise many interesting questions which are mostly too difficult for you to clearly understand. Although that is so, I hope you have begun to **wonder why a frog grows in this roundabout way,** and as we notice still further changes that your wonder will grow. In this way you may be prepared to hear some day how this wonderful riddle may, in part at any rate, be read.

LESSON XIII.

THE FROG, TOAD, AND NEWT.

A COMPARATIVE STUDY IN BEHAVIOUR.

[For this study the teacher should have under cover, *e.g.* in separate bell jars or inverted glass vessels, a frog and a toad, and some newts in water. In general the following points can usually be made out, although it will be understood that circumstances may arise here, as in other cases where the behaviour of animals is studied, that in individual cases departures from the normal may occur.]

The Animals at rest.—Compare the **attitude at rest** of the two animals, frog and toad. Do this by making an outline sketch. You will see that the frog sits with head directed upward and the greater part of the body raised off the ground. The toad, on the other hand, rests with the whole of the body lower down, its belly touches the ground, and its head is not pointed upward as in the case of the frog. Here are two references to the general appearance of the toad:—

> "Squat like a toad" (*Milton*).
> "The unwieldy toad" (*Wordsworth*).

In frog and toad the legs, fore and hind, are placed similarly. Notice how the toes of the fore leg point inward and the elbow is turned outward. Be sure and represent these correctly in your drawing (Fig. 35).

The Frog and Toad moving.—I shall now place the frog on the table and allow it to move. How does it progress? **By leaps.** I bring it back quietly and repeat the experiment. Sometimes I find the frog may crawl, but this is not usual. In most cases **the frog leaps.** In leaping the fore part of the body is slightly raised, the hind legs are suddenly straightened, and the animal is shot forward into the air. I now perform the same experiment with the toad. When it is set free in this way and seeks to move, **the toad crawls** away, step by step. Only occasionally does a toad seek to leap, that is when unduly excited.

Watch the toad crawling for a little. It moves sufficiently slowly for us to be able to **follow the separate movements** of the legs. All the four legs move forward at different times, but in a certain regular order. What is that order?

With a little patience in watching we discover that on the **right fore leg** being extended, it is followed by the **left hind leg.** Then comes the **left fore leg,** to be followed by the **right hind leg,** and so on. You should try to make a drawing of the animal in the act of crawling. Such a drawing should show the fore leg extended on one side and the hind leg of the other side drawn up close behind the fore one of the same side (Fig. 36).

Dispositions.—In handling these animals this way we discover that the **toad is a quieter** and much more easily managed animal than the frog. The toad, in fact, very soon gets accustomed to being handled, and behaves quite like a tamed animal. This is perhaps because it is not much molested by other animals. They leave it alone because it is not pleasant to eat. Its **skin is nauseous.**

Swimming.—I shall now place them in a large vessel of water. What a **delightful swimmer** the frog is. See how he shoots forward by the powerful strokes of his long hind limbs, aided by the webbed feet.

It will help you to **understand the frog's leaping and swimming powers** if you notice (*a*) that its hind limb from top to heel is as long as its body, and that its thigh is very muscular; (*b*) that its foot, from heel to tip of its longest toe, is as long as its leg; (*c*) that it has got a very fine web to its toes, and that its toes can be spread widely apart; (*d*) that it has a very prominent hump on its back. The hump is the place where the lifting is applied when the frog leaps, and as it is well forward on the body, greater power is got for jumping than could be got if it were further back (Fig. 35).

The toad swims well too, but it cannot equal the frog. Its hind limbs are not nearly so strong, nor so long, nor does it have so good a web on the foot. Compare the two and you will see this.

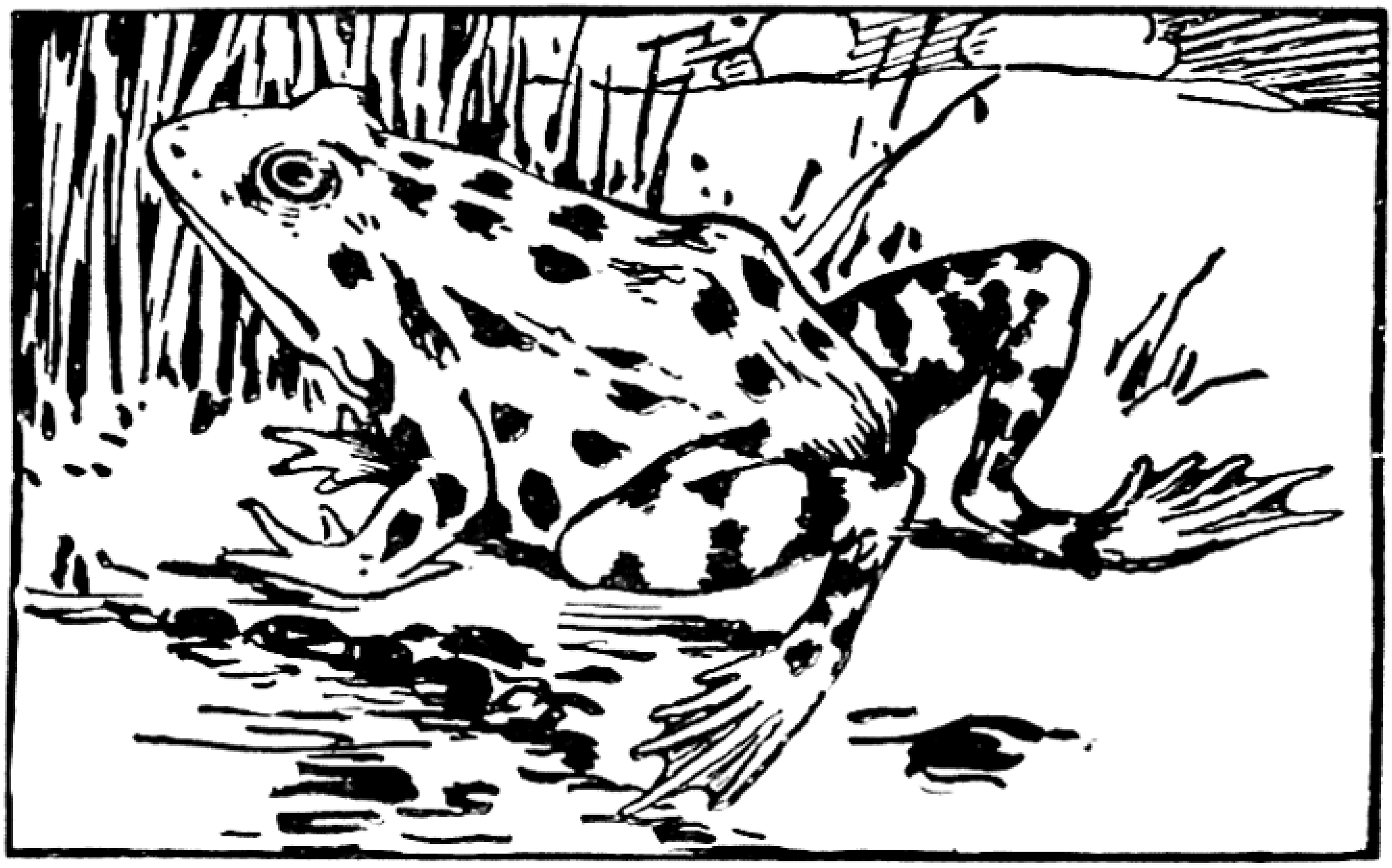

Fig. 35.—The Edible Frog (*Rana esculenta*).

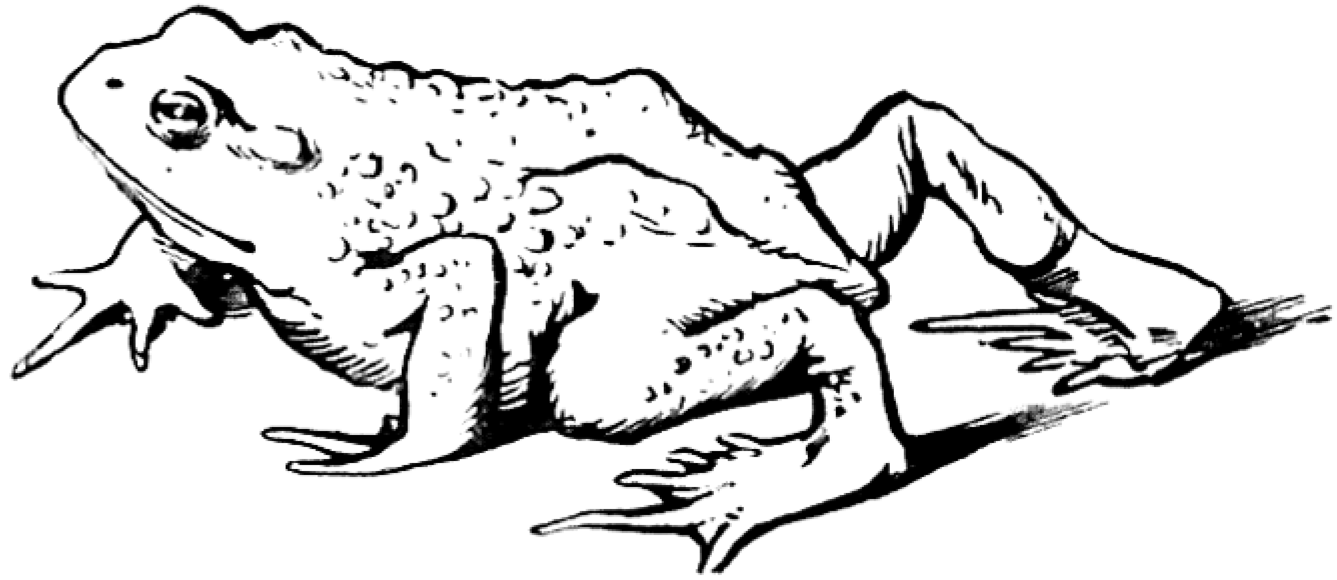

Fig. 36.—The Toad (*Bufo vulgaris*) in the act of crawling.

When left to themselves we notice the toad is less inclined to remain in the water than the frog. Toads do not frequent wet places so much as frogs. Notice that they have a much **drier skin**.

Food.—On what do frogs feed? They **feed upon insects,** many of which are captured when on the wing. The frog's tongue is attached at the front of the mouth, so that it can be shot out far. It has a double tip and is sticky. The insects are caught on it (Fig. 37).

The tongue of the toad is similar, but is not so useful in the same way as the frog's. Toads feed largely upon **worms, slugs** and **creeping insects,** such as beetles. Toads have no teeth, but frogs have.

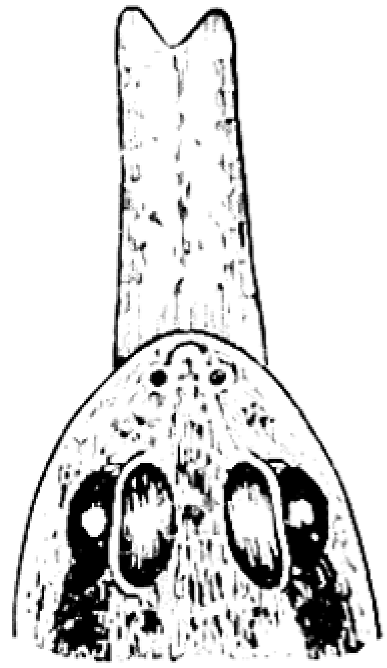
Fig. 37.—Head of Frog seen from above with tongue protruded.

Voices.—There is an interesting difference in the **voices** of these two animals. When I take the toad in my hand it sometimes speaks. I hold it by two fingers under the arm pits, allowing the hind limbs to hang down freely. It has a feeble, **harshly squeaking note.** The voice of our common frog is louder, **hoarse and croaking,** whilst that of the edible frog is still louder and more sonorous.

The Newt.—As an exercise, compare the movements of the newt with those of the frog and toad. This creature has a **powerful tail**, by which it swims. On land it walks in the same manner as the toad, but even more awkwardly. The tail, which in the water is so useful. on land is apt to drag heavily.

Draw in outline the newt crawling, as you see it from above.

Make the newt crawl upon a slate, and notice the wet track it leaves behind.

Feed the newt with a small worm, and watch its manner of dealing with it, or watch it "stalking" tadpoles when these are placed in the vessel beside it. They do this more especially when they are very hungry.

LESSON XIV.

GNATS IN THE POOL.

[In many ditches and other patches of standing water, including rain-water barrels, the early stages of the gnat may be found throughout the spring and summer. Different species may be found, but the general habits, especially of the young stages, are similar. The eggs are extremely small and are not likely to be found, although the larval gnats may be got at a quite early stage. They are well known to many children as "wrigglers" on account of their jerky movements in the water. A jar containing a number of these in natural water requires practically no attention in school, and by means of it the growth, habits, life-history, and structure may be followed with no difficulty. For demonstration purposes during lessons in school a small flat-sided glass vessel may be made of two rectangular glass plates (old photographic negatives do very well) glued to thin strips of rubber. This gives a vessel sufficiently narrow to prevent the gnats going out of view and permits easy observation of their behaviour. A hand magnifier can also be used with great advantage.]

Observation of the Larvae.—We have here in this jar a number of very active little animals. Let us look at them for a little.

As we watch them we discover that whilst a good deal of movement goes on, there is always a number resting quietly at the surface of the water. These give us a good opportunity of seeing what they are like.

If you draw a specimen in its resting position, you will in this way discover some interesting things. Notice how the creature's body is made up. As we watch it resting we see that it **hangs from the surface** of the water by a short tube-like part which is placed near the tail. The tail or hinder end of the animal is pushed a little to the side, whilst the tube hangs straight down into the water.

These two parts make a kind of V or L shaped end to the young gnat (Fig. 38).

From this part the body is made up of a row of joints like the joints in a caterpillar, but which, however, have no legs, although we can see they have a good many hair-like tufts. Close to the other end, that is the head end, there are two larger joints—first a quite big swollen one and then another not quite so big. This last is the creature's **head,** and on it you may see, especially with the help of a small hand magnifier, the eyes, a pair of short feelers, and a pair of feathery or hairy-like organs with which the gnat makes sweeping movements in the water.

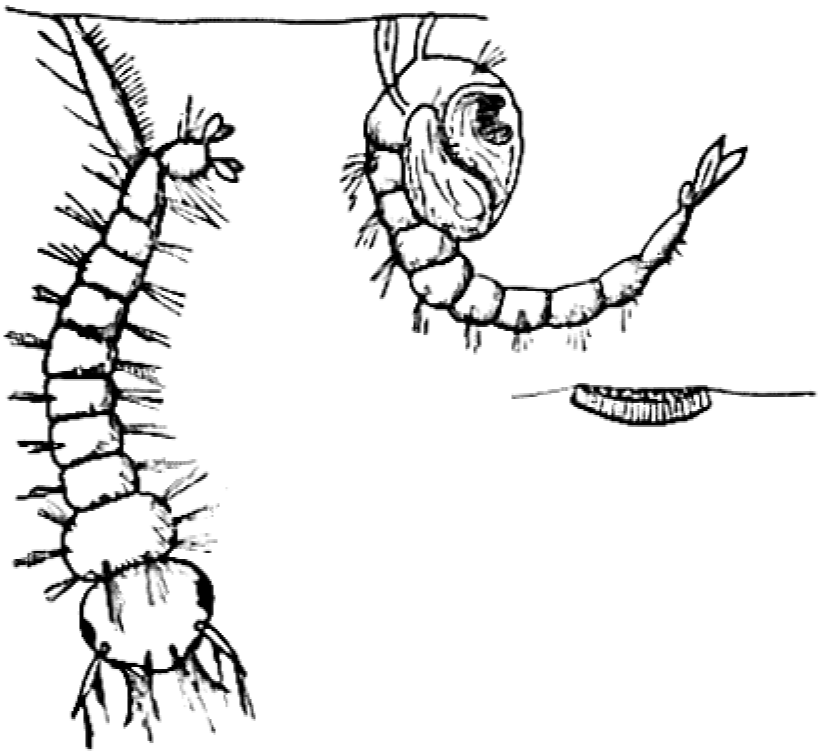
Fig. 38.—Larva, pupa, and egg raft of Common Gnat (*Culex pipiens*). The eggs are drawn upon a larger scale.

Its Breathing.—Now let us ask some questions. What is the gnat doing at the surface of the water? Why does it come there so constantly? It **comes there to breathe.** When this creature is fully grown it will leave the water for a life in the air as a winged insect, and there of course it will breathe air. There are some insects which live in water when young and whilst there breathe dissolved air as fishes do, by means of gills. But the young gnat does not do that. **All its life it is an air-breather,** even whilst living in water. The tube by which it hangs from the surface of the water is its **breathing tube,** through which it takes in air to the body.

Movement.—I would like you next to watch the gnats carefully for some time when they are **moving in the**

water. Disturb them slightly by gently tapping the side of the jar or by touching the surface of the water. Then watch the gnats as they move up and down. Have you noticed any difference in the way in which they move downward and upward? Do they not move downwards usually by simply **falling slowly?** On the other hand, we rarely see them rising in this way, but always by a doubling and **jerking of the body.** And so also when they pass from side to side of the vessel. Now try to answer this question. Is the young gnat heavier or lighter than water? If you are not sure, watch it again. It falls passively, but to rise it must jerk its body by doubling and straightening it. There is no doubt the **young gnat is heavier than water.**

The Surface Film.—Now remembering this, how is the gnat able to remain at the surface of the water to breathe? It can only do that by **hanging on to the surface film.** I think you already will have noticed that the surface of water holds together in a kind of film which is so strong that it is not broken by the weight of certain insects running upon it. Have you not watched the pond skaters (small insects) running actively upon the surface of a ditch or slow-moving stream? They have learned to so put down their feet that they do not pierce the film. And the film is so strong that it is **not broken by their weight.**

A Simple Experiment.—You should take a dry needle, place it across the mouth of a spoon, and holding the spoon close to the surface of a bowl of water allow the needle to roll off gently on to the surface of the water. If it fall quite horizontally it will float upon the surface, thus giving you a good proof of the strength of this film. The young gnat pushes the tip of its breathing tube through the film. This tip has **five movable parts** which surround the air opening. These parts on piercing the film spread outward, lying flat upon it. The tension between the parts is now sufficient to support the gnat without any effort on its part.

Feeding.—Whilst the gnat rests here it is busy feeding. Take a magnifier and look closely, observing the sweeping movements of the **brushes** in front of the mouth. With these the gnat is **capturing its food.**

An Exercise.—We have already noticed a difference in the way in which the young gnat rises and falls in the water. Now let us examine its movements. The gnat rises in the pool or swims sideways in it by doubling or looping movements of its body. Draw a line across a page of your note-book. Let this represent the surface of a vessel containing young gnats. If you figure in a row of gnats passing down the page below this line all having the body quite straight and nearly perpendicular, that will serve to represent the gnats falling from the surface.

Alongside these fill in a number of gnats having the body doubled upon itself as the gnat appears when rising in the pool. Arrange these from below upwards, with the tail looped in turn first to one side and next to the other. Then draw these, not in a straight line above one another, but always as they ascend a little to the right and left in turn of the perpendicular line. Such a drawing will suggest to you that the gnats are rising in the pool. Draw the gnats the natural size (Fig. 39).

Moulting.—We notice on keeping young gnats for a few days that they grow rapidly in size. As they do so there appear clear ghost-like creatures, shaped like the gnats themselves, also hanging at the surface. What are these? On taking out some upon a pencil we discover they are **empty skins** (cuticles) of gnats. These are the cast-off skins (moults) of the gnats which have grown away from them. This reminds us that the **outer skins of insects do not grow,** and that when the insects themselves grow they have to moult from time to time, replacing the old skin always first by a newer and bigger one from below.

Appearance of Pupae.—Besides the young active feeding gnats in the pool there early appear others of a different shape. There are plenty of them in our jar here. These are comma-shaped, having a thick oval-shaped forepart and a narrower tail portion curved below. When the vessel is left undisturbed for a time, where do these comma-like forms collect? They invariably settle at the surface. You may watch these for a very long time, using a magnifying lens, but you will never see them feed. These are the **pupae** of the gnat. They have arisen by moulting from the fully-grown young active gnat **(larva)** (Fig. 38).

Parts of the Pupa.—As the gnat pupa rests at the surface you have a good opportunity of looking at its various parts. Notice in particular how its back rests close to the surface, and that there are two small funnel-like tubes standing up through the surface. You will be able, I think, to say what these tubes are. These are **breathing tubes.** It is very interesting to note that these have changed their position from the tail to the back. I wonder if you know why.

The Pupa rests at the Surface of the Water for Two Reasons.—One is that it may **get air to breathe,** and the other is in order that when the winged insect is about to come out of the pupa skin **it may rise into the air** without getting wet. It must keep its wings in particular quite dry. Now the winged insect must come through the broadest part of the body, viz. the back, and this must be placed at the surface of the water. So now you see it is most convenient that the breathing openings should be on the part which for another reason lies at the surface.

The Pupae are Active.—If we tap the vessel or touch the surface of the water, what happens? The pupae dart away under, lashing their tails with great rapidity. As they rest at the surface of the water examine the tip of the tail with a magnifier. You can see in this way how well the tail is formed for swimming. You might almost have told beforehand that this creature would be a **good swim-**

mer. It has a broadly spread-out tail like a fan. A lobster has a very similar tail, and uses it in exactly the same way.

Now, you will remember that the pupae of insects are not usually active. The pupa of a moth or butterfly does not move about from place to place, but lies quite quietly. And this is the case with most insects at this stage. *Then why is the gnat different in this respect?*

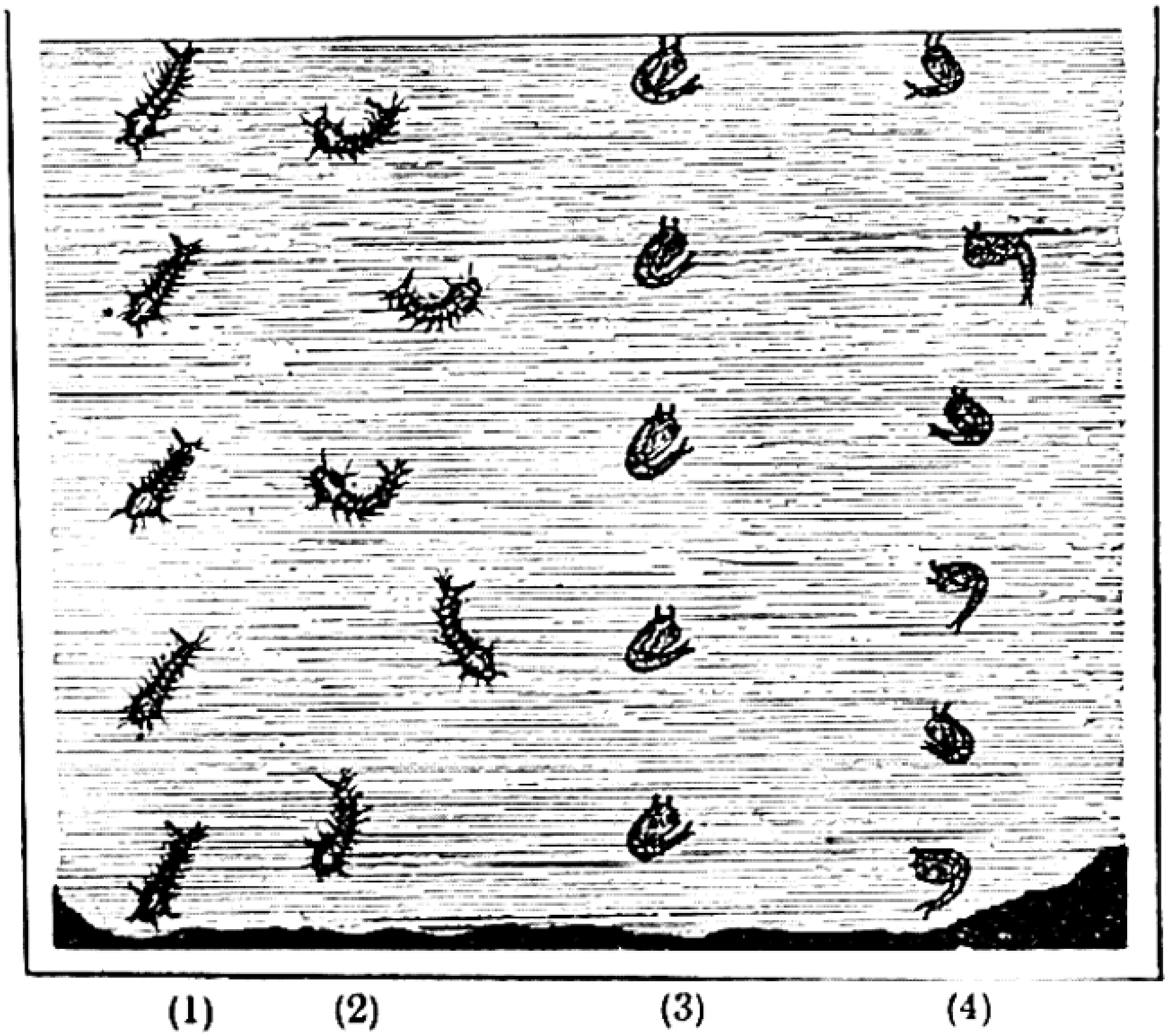

Fig. 89.—Diagram showing manner of movement of larval and pupal gnats. Row (1) represents the larvae descending passively, and (2) ascending actively; (3) represents the pupa rising passively, and (4) descending actively.

Well, you already know that the pupa must rest at the surface of the pool—that is in quite an **exposed place.** Why? But here the risks are of course great. The pupae are quite open to attack by animals such as frogs or toads, and would readily be eaten if they lay passively as land pupae do. But you see how readily they are disturbed and how active they become on the slightest hint of danger.

Their Movements.—Now you must study their movements more closely. Compare, with the same movements of the larva, the way in which they descend and ascend. When an animal moves without showing any signs of effort, we call that **passive movement.** The larva on letting go its hold on the surface film falls to the bottom. That is passive movement. How does the pupa behave? Is it not interesting to notice that exactly the **reverse behaviour** takes place? The pupa, by the lashing of its tail, rapidly passes to the bottom of the pool, but on ceasing its movements it floats upward to the surface also very quickly. You thus see that whilst the larvae are generally heavier than water, the **pupae are lighter** than water. And now we know the reason is to enable the pupae to rest without effort in that place which is most suitable for the winged insect to pass upward into the air (Fig. 39).

Emergence of the Gnats.—And now you must watch the jar daily in which the young gnats are living. After the pupae have appeared, the jar must be covered over with a piece of muslin to prevent the flies escaping. Some day you will see the insect coming out. You must then follow closely what takes place and write an account of what you see. When you see the gnat arising from the old pupa skin at the surface of the water and going off to live in the air, I hope you will wonder greatly why it should have such a strange life-history—that is, why it has come to pass that it spends any part of its existence in the water at all.

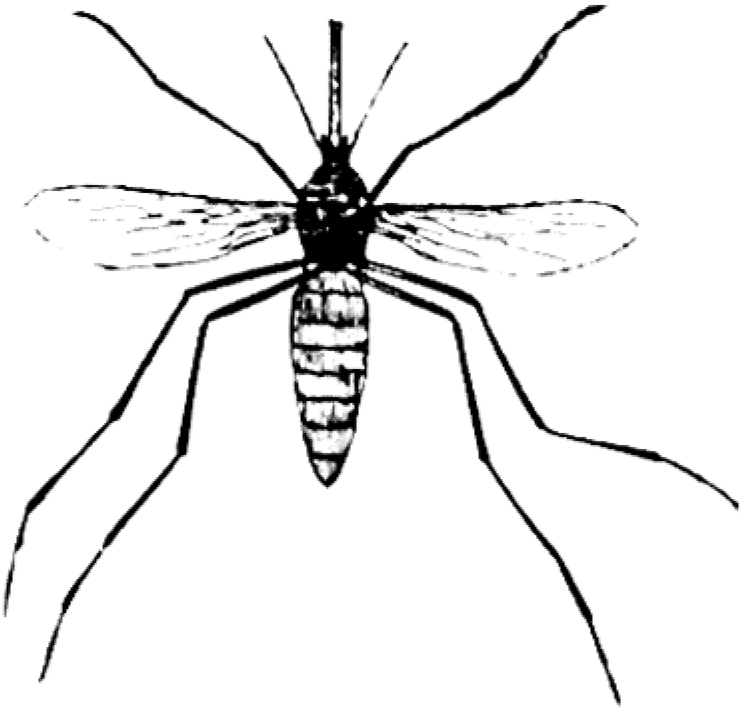

Fig. 40.—Female Gnat.

Before allowing the gnats to go take a good look at them with a lens. You will see that they have but **two**

wings, six long legs, and a **long proboscis** projecting in front of the mouth.

Make a drawing of an adult gnat (Fig. 40).

LESSON XV.

THE SKYLARK.

[The lesson should be given when larks may be seen and heard out of doors. If an actual (stuffed) bird can be exhibited to the class this will be useful in heightening the interest.]

In the lark we have one of the most interesting of the living creatures which are a feature of spring-time in our land. When the poet Browning wrote those fine lines,

> "The year's at the spring;
> The day's at the morn;
> Morning's at seven;
> The hillside's dew-pearled;
> The lark's on the wing;
> The snail's on the thorn;
> God's in his heaven—
> All's right with the world!"

he felt that spring was full of good things, and that the singing of the lark was one of them. And do we not feel the same?

General Attractions of Birds.—Birds are interesting to us in many different ways. Some attract us specially by their **power of flight,** others by their marked **care for their young,** others again by some special power in **nest-building,** some by their **sweetness** of song, or the **beauty of their plumage.** These are only a few of the many and varied interests of the life of birds. I do not need to ask you what is the special attraction of the lark. It is of course its **remarkable song.** You have all heard it, have you not?

The Lark's Song.—What are the qualities of the lark's song which make it remarkable?

(1) There is first its **great length.** No other bird sings for so long a time on end.

(2) Then the lark **sings on the wing.** He is the only bird with a song of any length which does this. We cannot compare at all the "caw" of the rook, the scream of the swift, or the cry of the curlews, gulls, or lapwings uttered on the wing with the song of any bird, far less with that of the lark. To sing and fly at the same time is **not an ordinary feat.**

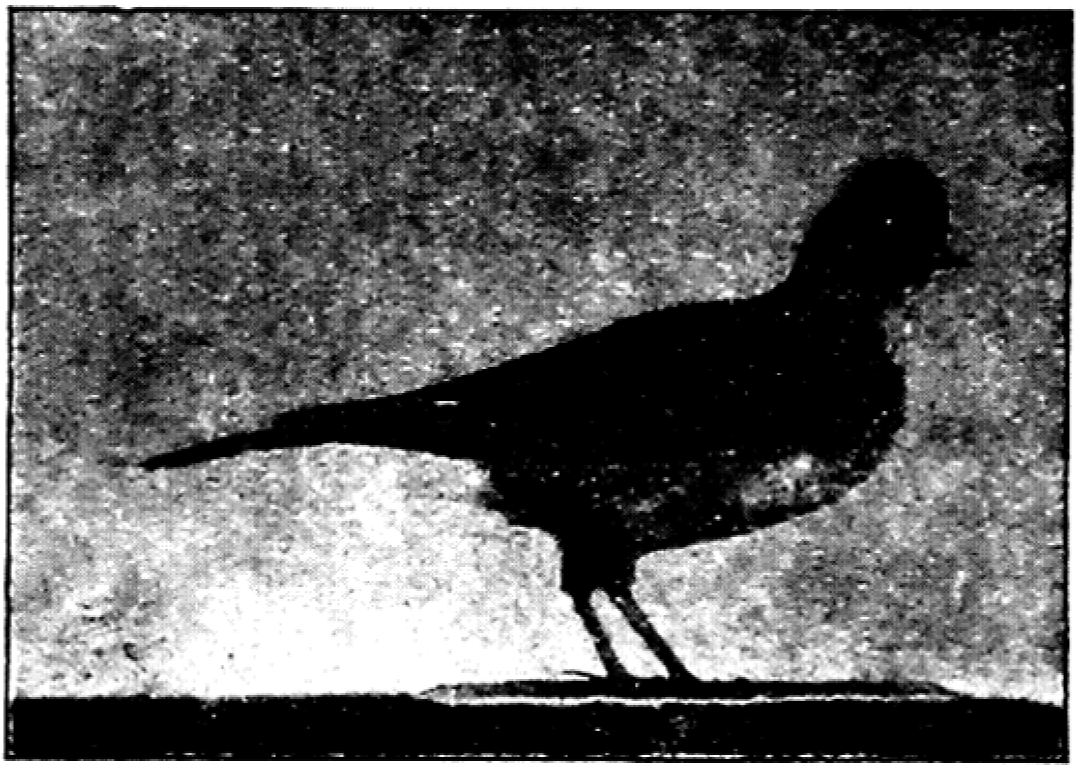

Fig. 41.—The Lark.

(3) Another thing about the lark's song which makes it very wonderful to us, is that it is sung while the bird is **rising in the air.** We notice that to sing and fly at the same time is a rare thing amongst birds and a wonderful, but to rise steadily into the air, away up to a great height, singing all the time is a greater feat and is a very good proof that the lark is a bird which has powers peculiar to itself. No other small bird ever seeks to rise so far into the sunlight. In thinking of this we are reminded of Tennyson's fine lines:

> "And drowned in yonder living blue
> The lark becomes a sightless song."

Wordsworth wrote a poem to the skylark, calling it a "pilgrim of the sky," in which he says, "a privacy of glorious light is thine." You must write down both these quotations in your book.

How does the lark manage to do it? Rising in itself is a remarkable feat. Observers have noticed that the lark always **rises with its head towards the wind,** and keeps its head to the wind. But it rises with very little wind. It **rises slantingly**, not going straight up, and with its **body at a high angle,** the head being higher up than the tail, its wings beating faster than 200 times per minute. It is quite true, too, that the lark can turn its wing at the shoulder further forward than most birds, and this turning is useful in giving a suitable tilt to the wings so that their strokes may cause the body to rise as well as go forward. But even when we know all this, do we not think the rising wonderful, especially when we remember that the bird is pouring out a song which would still be remarkable in its richness even if it were sung by the bird at rest? Sometimes larks do sing on the ground.

Is it not interesting too by way of contrast that this bird, so great a lover of the sky and sunshine, should have its nest upon the ground? Its singing in the sky, there is no doubt, is listened to with pleasure by the hen bird upon the nest, and is poured forth with all the more richness because of her presence.

The Nest.—What kind of a nest does a lark build? A very simple one; a slight hollow on the ground in open pasture or in a cornfield, lined with withered grass loosely put together along with hair or finer grass for a lining. Three to five eggs are laid. They are nearly an inch long, thickly mottled with a greyish brown or greenish grey colour. There are two broods in the season. The young are fed on insects and worms, but the grown birds include seeds in their diet. You should try to find a lark's nest, but be content with seeing it.

Winter Habits.—Have you noticed any difference in the winter habits of the lark as compared with those of summer? In winter they feed in companies, but not so in summer. Although larks are with us all the year there is a good deal of coming and going amongst them, and probably a good many of the larks we see in the winter in the British Isles are not the same birds as we have seen in summer. There seems to be a general moving southward and west to Ireland, whilst the numbers in Great Britain are added to by large numbers from the Continent.

The Appearance of the Lark.—Let us try to recall the appearance of the lark. It is a very ordinary looking bird, of a yellowish brown colour with a good deal of speckling. Notice in particular three distinctive things. The **bill slender and tapering,** there is a **light streak above the eye,** and the **claw of the hind toe is very long.**

If you have an opportunity of examining a lark, go over these points carefully and then make a simple sketch in your note-book of the bird.

LESSON XVI.

THE LAPWING (*Vanellus cristatus*).

[As in the case of other birds the lesson should be given when the lapwing is to be seen and heard out of doors. A stuffed specimen will be found useful. In those cases where there is a difficulty with regard to opportunity for seeing the birds a visit should be paid to a Museum for preparatory or revision purposes.]

General Appearance.—The lapwing is to most people a very familiar bird. It is best known by its cry—"Pēē-ŏ-wee"—hence the name Pee-wit.

I have here a specimen bird, which will be useful in letting us see conveniently what a lapwing is like. When we have examined it and learned some things about its life, I am sure you will look more closely when you see it out of doors, and take more note of what you see it do.

What is the most noticeable thing about this bird? Its **crest.** A fairly long upwardly turned slender tuft of black feathers. Do both cock and hen birds have a crest? Yes. Here are two references by poets to the lapwing's crest: Burns calls the lapwing, "thou green crested lapwing," and Tennyson wrote:

"In the spring the wanton lapwing
Gets himself another crest."

The crest is black you see. You also see why Burns speaks of the lapwing as green. Notice the **glossy olive-green back** of this bird.

What colour does the lapwing seem to have when you see it flying above you? It then **seems a black and white bird**. It is black you see at the neck. The most of the under side is white, and the tail is white with a broad black band at the end.

The lapwing is not a brilliantly coloured bird, yet it can fairly be described as attractive in appearance. The glossy reflecting green of the back, together with the contrasting black and white, are pleasing to look at. One of the chief things which interest us in birds is the great variety and combination of plumage colours which they exhibit, hence it is worth our while noting the colours and their arrangement in all the birds we study.

You should make a **coloured sketch** of the lapwing, so as to fix its appearance in your memory. As you do this you will notice its small head, rather flattened at the sides and rounded above. The bill is short for the size of the bird, and slender also. The eyes are large. The wings are large, the tail is broad, the legs are long with four toes, all with short blunt claws. You will see all these things as you make your sketch.

The Bird on the Wing.—You must watch the lapwings flying. They often wheel about for a long time, crying persistently. In spring at the nesting time their movements in the air are very noticeable; rising and falling, they glide along, wheeling in great circles. The flap of their wings, which are large for the size of the body, is rather heavy, and has earned them the name of lap-wing.

The Nest.—Have you ever seen a lapwing's nest? It is a very simple nest—just a **large shallow hollow on the ground** with a few grasses or straws loosely spread upon it.

Eggs.—The eggs are laid in April—four in number. They are nearly two inches in length, greenish grey or olive green, with spots or blotches of brownish black. I have here an egg for you to look at, and to draw and colour.

Protective Coloration.—When you look at this egg you must remember the kind of nest it was laid in and the colour of the earth round about. When you remember these things do you think the egg will be readily noticed? Not readily. The colour of the lapwing's eggs tends to protect them.

Protective Behaviour.—The lapwings are well known for the way in which they try themselves to protect their eggs or young. Sometimes they boldly fly around the intruder, or with **trailing wing** pretend they are hurt, and seek in this way to **draw** him off. Perhaps you have seen them doing this.

Young Birds.—The young lapwings are interesting. They have a brownish yellow down, and **can run** as soon as they are hatched. They protect themselves by **crouching** when they are approached. This is a habit which is practiced by many different kinds of animals when in danger. We can readily understand what it means, can we not? **Movement attracts notice,** and the animals, especially those coloured like their surroundings as young lapwings are, which keep still are those most likely to escape notice.

Food.—The lapwings are mostly feeders upon **animal diet.** They devour beetles, as well as their larvae, such as the so-called wireworm, and also other insects, water snails, worms, and, less often, seeds.

Wanderings.—These birds are with us all the year, on marshes, moors, and cultivated land. Many of the lapwings of Great Britain go to Ireland in winter, others to the South of Europe, *e.g.* Portugal.

The Web of Life.—The lapwing illustrates in an interesting way the manner in which the lives of living creatures, not apparently connected, are bound up with each other. The lapwing feeds upon a well-known small **water snail** (*Lymnaea truncatula*) which lives in marshy places, such as wet meadows. Within the body of the snail there sometimes lives a young **worm parasite** which lives as an adult in the **sheep.** The sheep suffer seriously from this, and frequently die from what is called "liver rot." The snail infects the grass with the worm. The sheep, in eating the grass, swallow the worms, and then suffer. The more lapwings there are, the fewer are the water snails; the fewer the water snails are, the fewer are the worm parasites and consequently the safer are the sheep, and of course the wealthier are the sheep farmers.

But many people, especially in London and other towns, are fond of lapwings' eggs. Every year very large numbers are collected and sold. It is quite true that in consequence of this lapwings, especially in the South of England, are getting fewer. They are getting fewer in Scotland also. So now you see the more the wish for lapwings' eggs is gratified to the town dweller, the more the sheep farmer suffers. And not only the sheep farmer, but all farmers, because lapwings are not only useful in eating pond snails, but most of the insects they devour are destructive to farm crops.

The lapwing is an interesting and a useful bird, and you should protect it in every way that you can.

An Exercise.—Write out a list of the different ways in which lapwings are protected:

The eggs are protected by their resemblance to their surroundings.

The parent lapwings divert the enemies of their eggs and young. They are more successful in this with animal enemies than with men.

The young lapwing is protected by its colour and by its habit of sitting still when in danger.

It should be recognised that although all of these methods fail in a certain proportion of cases, they are yet of **life-saving value** in the long run to the greater number.

LESSON XVII.

THE CUCKOO (*Cuculus canorus*).

[The lesson will be most effectively taught about the time and in places where its voice may be heard or its egg observed in a nest. A well-taught lesson is more than justified *without a specimen bird.*]

The cuckoo is better known to most people by its voice rather than in any other way. Many people have heard it, but not many get an opportunity of seeing the living bird. The cuckoo has a number of interesting features about it. Let us take note of some of them.

Time of Arriving and Voice.—Why are most people interested in the cuckoo? There are several reasons. One is that to them the bird is a voice only. Another is, it is a voice which when heard the first time brings a message. The cuckoo's first notes mean the return of the wanderer, and that means the return of spring:

> "Thrice welcome, darling of the spring
> Even yet thou art to me
> No bird, but an invisible thing,
> A voice, a mystery."
>
> —WORDSWORTH.

I hope you have heard the voice of the cuckoo.

Do you know how early in the year it may be heard? About the second week in April in the South of England.

When you hear it the first time write it down in your Nature Calendar, and be ready to hear it again at the same time in the following year. Notice, too, that you may hear this bird late at night or in the early morning as well as by day. Do you know which bird, male or female, makes the "cuckoo" cry? It is the male bird. Have you heard it said that "in June, he changes his tune?" By this time his voice has become hoarse and the familiar mellow note is no longer heard. The female utters a different kind of sound, which has been described as a "water bubbling or whistling note."

Length of Visit.—Another thing besides the voice of this bird which makes the cuckoo interesting, is the fact that it pays our country a very **short visit.** It is amongst the first of our migrant birds to leave, the parents departing in August for Natal, in Africa. The female is said to come to the same locality year after year.

Habits.—The cuckoo is a noteworthy bird in another way, viz. in that it does not rear its own young, but leaves them to the care of another bird.

Can you tell how this is done? The cuckoo's egg is placed in the nest of some other bird. The parent cuckoos do not build a nest of their own. I am not sure that anyone has actually seen the cuckoo placing the egg, but from the nature and size of some of the nests in which cuckoos' eggs are frequently found, it is very unlikely that the egg is laid in the nest. More likely the cuckoo lays the egg on the ground and places it with her bill in the foster-bird's nest.

A cuckoo is about 14 inches long from bill to end of tail, but its egg is not more than $\frac{11}{12}$ of an inch long, so that it is a **small egg for the size of the bird.** The same bird may lay from five to eight eggs in the season, and sometimes puts more than one into the same nest. Notice, too, that as the cuckoo is an early arrival in this country, her eggs are laid early and hatch out soon. The **colour of the eggs varies** a good deal, and it does not seem to matter whether they resemble the other eggs in the nest or not. Sometimes they are like them and frequently they are not.*

The foster-parents do not remove the cuckoo's egg but hatch it out. There are more than fifty different birds at least into whose nests cuckoos place their eggs. Examples are: hedge sparrow, meadow-pipit, bullfinch, wren, swallow, etc.

Young Cuckoo.—What happens when the eggs are hatched? The young cuckoo is larger than the other young birds and behaves in a very extraordinary way. The foster-parents feed it along with the others in the nest, but very early it throws the other young birds out of the nest. There is a peculiar **hollow between its shoulders** by means of which it is able to hoist the other birds over the side of the nest, and this hollow fills up when the bird is about twelve days old.

The remarkable thing is that the foster-parents continue to feed the young cuckoo, which grows so big and requires so much food that they find it very hard work. It becomes a very ridiculous sight in the end, the big hungry bird demanding food from its foster-parents who are smaller than itself.

Migration.—The parents migrate in August, and the **young cuckoos follow** by themselves in October. In their case at any rate the birds find their way without the aid of their parents. Behaviour like this, in which the birds perform a difficult feat without training or previous practice, is called **instinct.**

Appearance.—The grown cuckoo is a slender and graceful bird of about 14 inches long. It is bluish grey above, the front and sides of the neck are lighter, the under parts of the body are bluish white with narrow brown bars running across. The upper sides of the wings are brownish. There is a long tail of dark grey which is white at the end. The bill is slender and has a slight hawk-like downward curve at the tip. It is perhaps owing to this faint resemblance to the hawks, coupled with their disappearance in autumn, that the somewhat ancient suggestion arose that "cuckoos turn to hawks in winter."

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* For fuller notes on the egg laying habits of the cuckoo, see the author's *Nature Study*, p. 121.

An Unusual Instinct.—We cannot admire the strange instinct of this bird which leads it to desert its young, or the still stranger instinct of the young cuckoo which destroys the life of the unfortunate birds whose parents have hatched it out. Perhaps the strangest thing of all is that the foster parents should rear the young cuckoos, for in so doing they appear to be acting against the interests of their own race. When you are older you will hear much about the "struggle to live" which goes on amongst all classes of animals. This struggle is seen in many different forms, but there are few which are so strange or so difficult to understand as that which involves the sacrifice of the rightful inmates of a nest for the sake of a stranger and which uses the parental care and energies of the owners on its behalf.

LESSON XVIII.

SWALLOWS, MARTINS, AND SWIFTS.

[This lesson might well be taught when these birds arrive in the spring. The swallows will probably be seen first, in the month of April, the swifts not usually arriving until early in May, when the lesson might suitably be given. In a lesson of this kind it is not essential that specimen birds be utilised, although where stuffed examples are available they may be used. What is important is that the observations suggested in the lesson should be carried out.]

THE SWALLOW (*Hirundo rustica*).

The Coming of the Swallow.—Amongst the growing delights of the spring and early summer do you not include the birds? When we hear of the spring arrivals amongst these, is there not one bird which always comes readily to mind, viz. the swallow? The coming of the swallow is an **important seasonal event.** This is one of the things you must put down in your school Nature Calendar every year—the first day the swallow is seen in your neighbourhood.

Some Questions.—Does the swallow keep good time? Those who watch these things tell us that it does. When you begin to think of this little bird, do you not feel there are a great many questions you would like to ask about it? Here are some, I am sure: Where has it been all the winter? You know in a vague way it has been far away—somewhere in Africa likely. Do the swallows come back to the same place? Some at any rate do, we know—even to the same nesting place. Birds which have been captured and have had numbered rings placed on their feet have been recaptured at the same place the following year. Why do they go and come in this way? That is a more difficult question. It is partly answered when we say that they go because of **scarcity of food** and to **avoid the winter,** and they come back because it is **healthier for the young birds** which are to be hatched during the summer.

How do they **find the way?** This is a still harder question. We scarcely know. It is one of the wonderful things in the life of a bird, more remarkable perhaps than you even thought of at first, for in most cases the young birds go off in autumn on their first journey in front of the older birds. They have some means of finding their way which we cannot clearly understand. Some people think they have a "sense of direction"—that is, that they somehow **feel** the right way to go, rather than see it.

How is such a small bird able to go so far and to go so fast? We cannot answer these questions clearly either. Yet as we watch the seemingly tireless flight of the swallows, wheeling and dashing past us so swiftly, we scarcely wonder so much, so active are they, and so easy do their movements seem.

At the same time we must not forget that numbers fall out by the way, and that it is only the strongest who are able to perform these remarkable journeys.

Appearance.—When next you see the swallows flying you must try to **get a good look at them.** If you can see one at rest, too, you will be able to make out its appearance better. You will find that it is a very small bird, of slender and graceful form. A male swallow measures from the tip of his bill to the tip of the longest tail feather about 8¾ inches, the female about 7¾ inches. But as the tail is very long you will see how very small and fragile looking the body by itself really is.

The wings of the swallow are long and rather narrow. They measure 14 inches from tip to tip when spread in flight. The tail is deeply forked, the outside feather on each side is longer than the others, very much so in the male swallow. **Long narrow wings** and **deeply-forked tail** are two things which go along with good flying powers, and quick turning and wheeling movements. **Watch the swallows** closely, and after you have studied them for a time make an **outline drawing** to show their shape with outspread wings (Fig. 42).

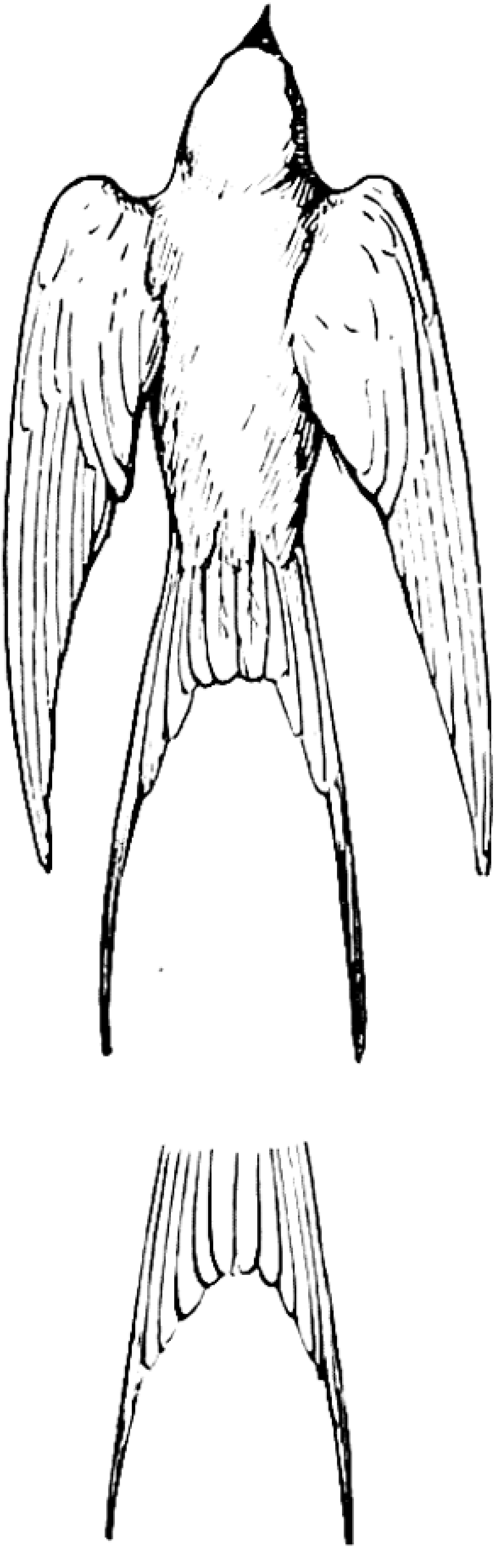

Fig. 42.—Male Swallow; tail of Female. Note the short broad bill, slender body, narrow wings, and forked tail.

Feeding Habits.—It is very important that a swallow be able to fly swiftly, and to turn or change its direction with the greatest suddenness. Can you think why? This is because of the food they eat and the way in which they obtain it. A good place in which to study the feeding of the swallows is near the banks of a stream when the water-haunting insects are dancing over the surface. There you will see how they feed. Or you may watch them chasing the moths rising from amongst the long grass on a summer evening. Another insect they hunt is the hop greenfly. This is a very small insect.

Before a bird can chase flying insects, some of them very small, and depend upon them entirely for food, it must have great power over its movements and be able constantly to change their direction with great swiftness. All this the swallow is able to do by means of its long tapering wings and deeply-forked tail.

Mouth and Bill.—Unless you have been quite close to a swallow you cannot tell what kind of a mouth it has. Its bill is quite short, but its gape is very wide, and this helps it the better to catch the flying insect. The swallow's tongue is cleft at the tip. When you remember the food of the swallow you will readily understand how necessary is migration before winter to a country where insects are common. Swallows would starve if they were to remain, for we have very few insects on the wing in winter. We sometimes hear of swallows being left behind in winter, and these die if they are not taken care of.

Colours.—The swallow is beautifully and delicately coloured. Above it has a deep blue gloss, around the bill a warm ruddy tint, and underneath the body is light coloured, almost white in a female bird.

Nest and Eggs.—Have you seen the swallow's nest? It is usually made about buildings of some kind—amongst the rafters of a barn, about chimneys, or under the eaves of houses upon a projecting ledge. It is made of mud and bits of grass or straw mixed, lined with soft feathers, and is thick and shallow, like a saucer. It is not a very neat nest, and somehow is not quite what we would expect in a bird of many graceful habits.

The eggs are small, white and dotted with brownish spots. If you ever see the swallows nest-making you should try to get a look into the nest if it can be reached without danger to yourself. There are two broods of swallows reared in a season. Fed first in the nest, and later on the branch of a tree or other support, the young birds eventually come forth to meet their parents, receiving food whilst on the wing.

Summary of Observations.—Let us sum up the things you might do to understand the swallow better.

Look out for their arrival in the spring, and make a note of the date.

Compare the swallow by its outline and flight with other birds of similar habit. Draw a swallow in full flight.

Watch the swallows nesting and feeding their young. If possible look into the nest and get to know the eggs.

Watch the birds feeding.

In autumn take note of their gathering on telegraph wires, and in the neighbourhood of ponds before they start upon their autumn journey.

THE HOUSE MARTIN (*Chelidon urbica*).

Another bird which is somewhat similar in appearance is the house martin, which arrives soon after the swallow.

You should try to distinguish the two.

Comparison with Swallow.—It is not difficult if you get a close view. There are no long tail feathers in the house martin, nor are the wings quite so long.

The colour above the head and back is of the same steel-blue tint, but there is no ruddy colour on the throat or above the bill.

The hind part of the body above at the **base of the tail is white.**

The under side of the body is mostly white.

When the bird is flying especially low down the white above the tail is conspicuous and by it the bird can be readily recognised.

Nest.—Its usual nesting place is against a wall in the shelter of a projecting ledge, or in the corner of a window (hence called " window swallow "). Sometimes the martins nest on cliffs.

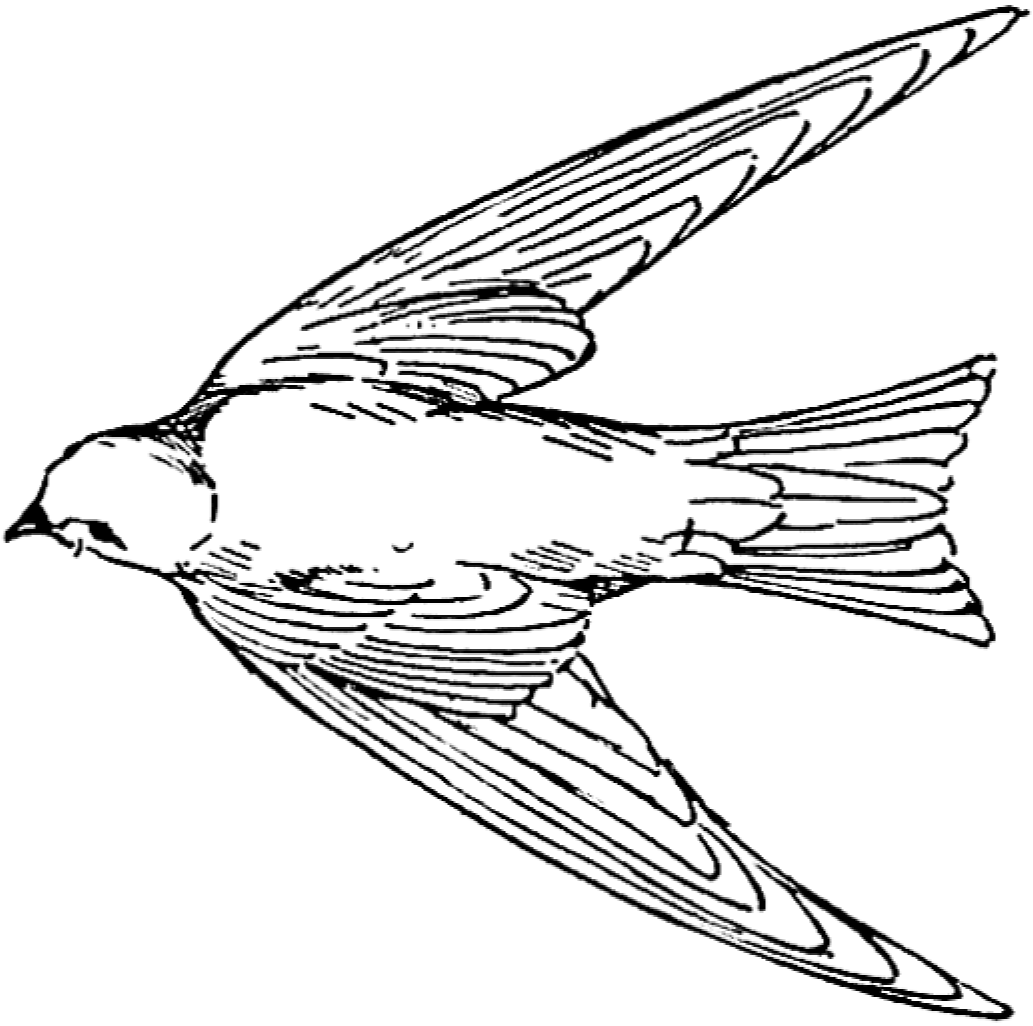

Fig. 43.—The House Martin.

The nest is differently shaped from that of the swallow. It is bowl-shaped, closed in all round the exposed part, with only a small opening at the top. It is made of mud and straw, lined inside with feathers. The eggs are pure white, four or five in number, and here as in the case of the swallow two broods are hatched in the season.

If you can get a good view of the house martin as it flies past overhead, try to notice its shape in flight and make an outline drawing of it (Fig. 43).

THE SAND MARTIN (*Cotile riparia*).

This bird is not so well known as the swallow and house martin. Its nest is usually more remote from human dwellings, being placed at the end of a fairly long tunnel which is scraped with bill and claw in sand banks. It is a shallow structure, formed of straws and lined with a few large feathers. The eggs are pure white, and here also there are two broods. The bird is slightly smaller than the house martin, is coloured **greyish brown** above and across the breast. The lower parts are lighter. The tail is slightly forked, the wings moderately tapered. The sand martin arrives about the same time as the swallow, but leaves earlier, viz. about the middle of September.

THE SWIFT (*Cypselus apus*).

Appearance and Habits.—The swift is an interesting bird, which is with us only for a short time each year. It arrives in May and leaves again in August. It is a very **easily recognised** bird. Its habits are similar to those of the swallow or house martin, with which it hunts its food. It is a splendid flier.

There are two ways in particular by which you recognise the bird. Do you not know its **shrill, screeching-like note,** which comes upon you so suddenly as the birds flash past, sometimes, as it seems, almost close to one's head? This note or scream is not like that of any other bird. Then **the shape** of the bird upon the wing distinguishes it from all others. It is slightly larger than the swallow. Its wings are much longer, and when they are spread in flight they form a fine even curve like an arc of a large circle with the head of the bird projecting through. Another comparison that has been made describes the wing of the swift as scythe-shaped. The front edge of the wing has the same curve as a scythe. The tail is forked, but it is broader than that of the swallow and has not got the long outer feathers. The swift is blackish in colour, with a lightish patch below the bill.

It has the same kind of bill—broad, short, with a wide gape—as the swallow. **You may see the swift** in the evening or early morning dashing and wheeling through the air, coming close to the ground or skimming the surface of a stream, then rising high in the air at other times and soaring with even wing. It is then that you see clearly the real shape of the flying bird.

An interesting thing about the swift's foot is that all the toes are turned forward. It is not well suited for perching, but it can cling very well to walls and cliffs. When they settle upon the ground they cannot rise so easily as most birds; this is partly due to the length of the wings.

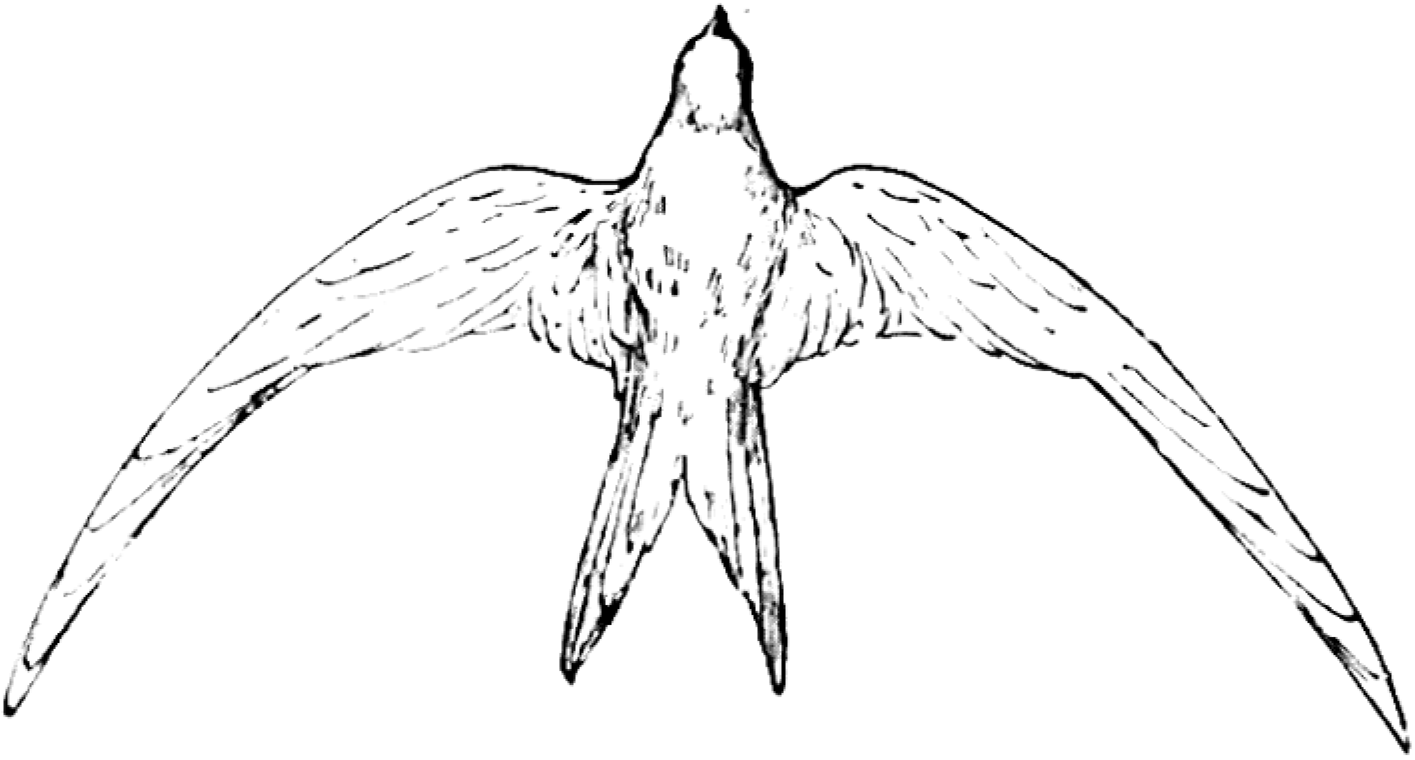

Fig. 44.—The Swift. Note the great length of the wings.

Nest and Eggs.—The swift nests in crevices in cliffs, about towers, under the eaves of houses, and other conconcealed places. The nest is made of straw, grass, hair, feathers, and such like rudely put together. The eggs, which are about an inch long, are two or three in number, and pure white.

You must try to **see as much as you can** of the swifts and take notice of their remarkable powers of flight. Make a companion drawing of the swift beside those of swallow and martin, so that you may tell by the shape alone any one of these three birds (Fig. 44).

An Exercise.—Write out a list of the more remarkable things about bird life which these birds are very good examples of.

(1) The habit of migration.
(2) Excellence in flight.
(3) Feeders on flying insects.

General Note.—These birds are not very good at nest-making, but they build in "safe" places mostly. That is, places which are not easily reached by egg-stealers amongst animals. Their nests are mostly dark, and their eggs are pure white, except those of the swallow, whose eggs are spotted over the white. There is perhaps some connection between dark nests and white eggs. You will hear more about this in the lesson on birds eggs (p. 194). None of these birds are notable songsters, although the swallow and martin have a very pleasing low twittering note at the breeding season.

[The methods of treatment illustrated in the lessons on birds are adopted to suit the special conditions under which such lessons must in general be taught. They are also meant to indicate the lines upon which the teacher might frame others upon familiar birds (or mammals) in which the pupils are, or may be made to be, interested, but which circumstances do not admit of being exhibited in school. The restriction of the course to such lessons only as can be illustrated by specimens, is bound to rob it frequently of the best materials, a knowledge of, and an interest in which are essential to our aims in Nature Study.]

LESSON XIX.

THE WANDERINGS OF THE EEL.

[The teacher should endeavour to secure some elvers for the purposes of this lesson—alive if possible, and also an adult eel. Pupils should draw the eel.

The main facts brought out in the lesson should be written out by the pupils somewhat after the following manner:

1. Eels perform two journeys.
2. One at the beginning of life—as elvers.
   Another at the end—as silver eels.
3. They hatch in sea and swim to the fresh waters.
4. They are about one year old when they arrive at the fresh waters of our country.
5. They live from four to seven years in fresh water.
6. They change from yellow eels to silver eels before leaving.
7. When they return to the sea they spawn and die.

The teacher should get a yellow eel and a silver eel (from shops is easiest) towards the end of the year and show both to pupils.]

To many people one of the wonders and interests of the spring-time in our land is the coming of the eels. I wonder if you have heard the story of the wanderings of this most interesting fish? I have no doubt most of you have seen an eel; alive in a stream I hope. More of your number have seen them in the fishmonger's shop; perhaps you have eaten them and enjoyed the feast.

The fascinating thing about the eel is that it performs

two very remarkable journeys

in the course of its life. One of these is at the beginning and the other at the end. Between the two there is a period from about four to nearly seven years which is spent in our rivers and streams. During this time the eels feed and grow, until from being **about three inches** long on the average at the **end** of the first journey they may be **two feet** in length when they **start** upon the second. Remember these two dimensions.

The First Journey.

In spring or early summer, if you live near a river, you may be fortunate in witnessing a very interesting sight. This is nothing less than a long **procession up stream in** almost countless numbers of young eels. They are very small, their shape is like that of a big eel, they are from two to four inches in length, and are transparent. They may be seen from the bank quite easily, because they swim near the surface and not far from the edge of the stream. Perhaps they do this because the current is not so strong here, or because companies break off at each tributary stream. On they go, ascending to the highest streams and lakes, stocking the waters afresh, until practically all the streams of our land are repeopled with a fresh race of eels. At this stage they are commonly called **"elvers."** I am sure that some of you are quite familiar with them.

Personal Observations.—Those of you who live near a stream should keep a look-out for the arrival of the elvers. The time is of course not quite the same in different streams, but once you have discovered them in any year, be sure you keep a note of the date so that in following years you may be able to enjoy this most fascinating sight. It will not be difficult for you to capture some and to keep them alive for a time.

Questions.—While we watch the elvers, there are many questions which occur to us. I hope you will get a chance to see them, and that the questions will puzzle you. There is the question: **Where are they going?** We shall take that first, because it is not difficult for you to answer. They are going, as we have just mentioned, to distribute themselves throughout the fresh waters of our country. In the course of the summer they will darken in colour, becoming more like the bigger eels. They are already very hungry and feed greedily. They are in fact on their way to live the ordinary life of an eel in fresh water.

Where have they come from?—Now if you think for a moment you will not find it difficult to answer this question either. Are they not all ascending the stream. Just as surely as the waters of the stream are flowing down to the sea is the stream of elvers flowing up from it. They are coming from the sea. But this is only part of the answer.

How old are they?—I think you will likely ask that question—I hope so. It is a little difficult to answer exactly, because that will depend upon the place you live in. But this is practically certain. None of them are under a year old. Now that answer should puzzle you. A year is a long time in the life of a fish. **Where have the elvers been all this time?** The answer is: travelling nearly all the time. They have come through the sea hundreds of miles, and in some cases over a thousand miles before they reached the mouths of the rivers at all. They are hatched out in deep water in the Atlantic Ocean, hundreds of miles away to the west of the British Isles. Some of the eels which are hatched here travel as far as the inner waters of the Baltic Sea covering not less than 1600 miles.

Another interesting thing is that the elver has twice gone through **changes of shape** before reaching the elver form. First it was slender, and had fine long teeth in its mouth. Then it became very broad and flat and transparent, with a very small head. At this stage it may be 3 inches long, and is not at all like an eel in shape. It is more like a piece of tape narrowed at the ends.

How do we know all this?—Our knowledge is due to the investigations of scientific men who have studied fishery problems. The story of how these things have been proved is very interesting; you may hear it some day when you are older.

How do the elvers find their way?—We scarcely know anything about this. It is very marvellous to us when we think of these small creatures pursuing their steady march through the sea. The sea has been called a "trackless waste," but somehow the elvers are able to cross it without going astray. We must not forget that it is quite a **new journey.** They have never been this way before and there are no grown eels to show them the way.

When creatures do a remarkable thing like this successfully without any training or help, and without having done it or tried to do it before, we say the action is done by **instinct.** The ability to do it is part of the animal itself just as much as any part of its body is. But for us it is just as good to say: it is all most wonderful to think of and delightful to know.

Compare the journeys of birds.

THE SECOND JOURNEY.

But the journey through the sea and up the streams is only half the tale. After living for some years, it may be for four and a half years in the case of male fishes and several years longer in the case of females, a change comes over them.

Changes.—From being yellowish in colour they become lighter. The change is quite marked, and they are then known as **silver eels.** Silver eels may be got in the end of the year. The change in colour is not the only one. By carefully comparing the two kinds—yellow eels and silver eels—these other things have been discovered.

1. The eyes of the silver eel are larger and nearer the top of its head.
2. The smelling organ of the silver eel is improved. Its sense of smell is therefore keener.
3. The line on the side of the body, which is a line of special feeling, is clearer and more distinct. The silver eel will thus have a better sense of touch for certain purposes.
4. The breast fins of the silver eel are larger.
5. The silver eel has much fat upon its body.

What is the meaning of all this? These things are the eel's **preparation for a long journey.** In becoming altered in these ways it is really becoming changed into a **deep sea fish.** After the eel has become a silver eel it proceeds **down the stream** to the sea. This is the eel's second journey. It is a return journey this time. The eel goes back to the place in the Atlantic Ocean where it was hatched, and by the time it gets there it is ready to spawn, and from the eggs a fresh race of eels will arise. Eels travel at the rate of about eight to ten miles per day; some go slower and some faster. They leave the streams about October or November; the journey takes several months, and during all this time they **do not stop to feed.**

What becomes of the eels after this journey is completed? They disappear out of our ken. It seems quite certain that this is the **end of the tale.** They die and their place is taken by the young ones, who set out upon their long and marvellous journey to the streams which their parents left some months before.

Why should the eels perform these remarkable journeys? That is a question which you must remember, and ask when you are older. Even then I do not think you will get a complete answer, but you will be told something which I am sure will rather add to than take from your interest in this familiar fish.

LESSON XX.

THE MOLE (*Talpa europaea*).

[Moles are frequently abundant in certain districts, and are generally easily obtained. Their "hills" are numerous in spring, and at this season a lesson upon the special features of the animal in relation to the life it leads is appropriate. When a fresh dead mole is secured a lesson on the following lines might be given.]

Here is a very familiar animal, the mole. Where does it live? It lives underground, making tunnels along which it runs, throwing up the the earth in the familiar "molehills."

Now we are to look at the body of the mole so that we may see how it has become specially fitted for the underground burrowing life which it leads. As far as the various parts of its body are concerned they are just the same as those of any of the furred animals which live above the ground. But the more we look at the bodies of animals the more clearly we come to see that each kind has the parts of its body specially suited or shaped to fit it for the life it has to lead. And we shall find that the mole is an excellent illustration of this.

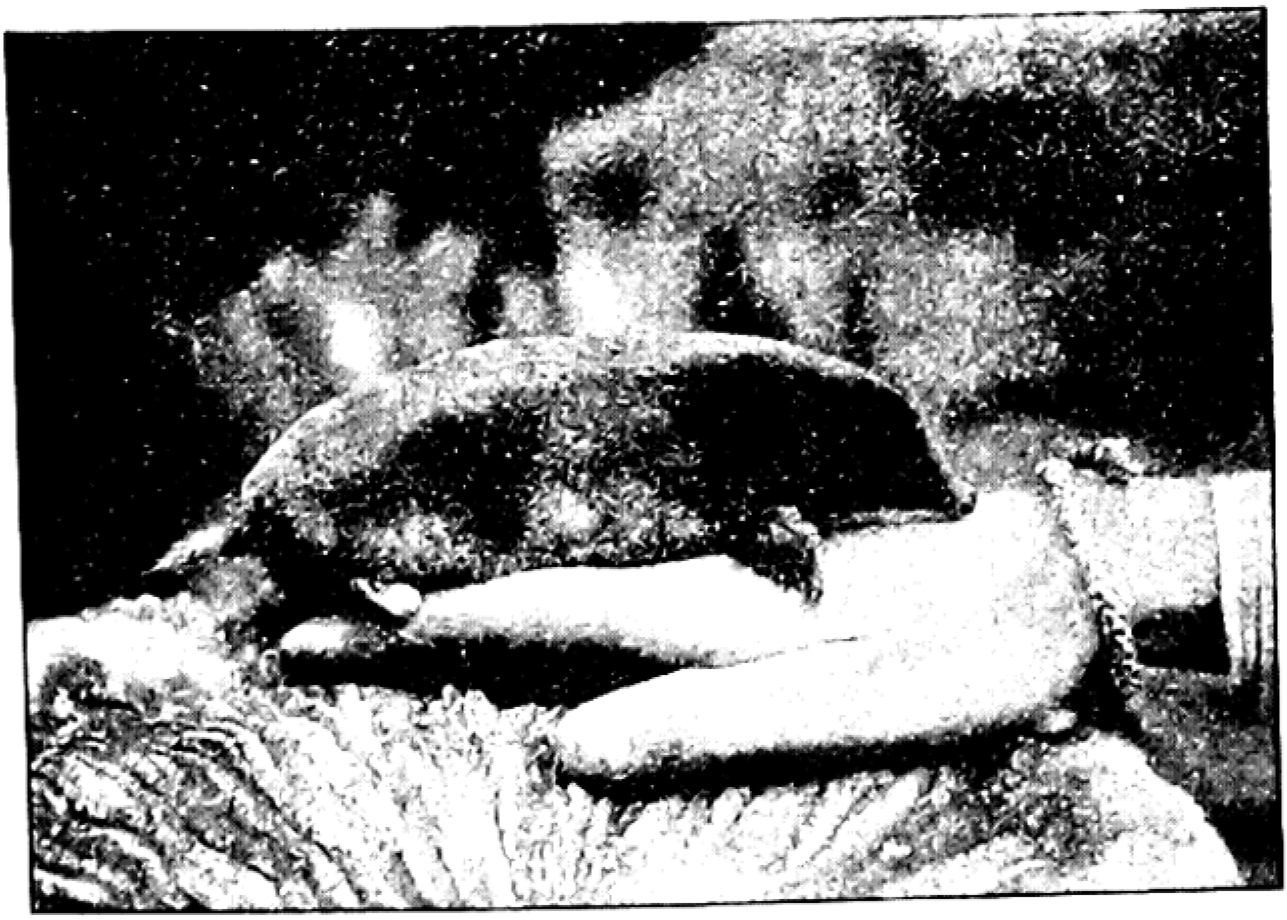
Fig. 45.—The Mole.

The Shape of the Mole.—I take its body in one hand and gently draw it through the other. If you do the same you will be struck with the evenness of its shape. It feels long and evenly rounded, the same thickness at the hinder part of the trunk as at the shoulders. There is here none of the curves of back and neck which mark the shape of most furred animals. Think, by way of contrast, for example, of the arched back of the mouse or squirrel, or of the rounded curves of the neck and back of the stoat or of the weasel (Fig. 46).

The mole moves in a narrow cylindrical burrow, made just big enough to allow it to run along, but not much larger. Why is it best that the burrow should be narrow? A wider burrow would not only make extra digging necessary on the part of the mole, but would give a better chance to enemies to follow, as well as make the burrow more liable to fall in. The mole then has no spare room, and its way of moving needs none of the arching curves we have spoken of. **A cylindrical shape is the best shape** for a creature living this kind of life, and that is the shape of the mole. This is a good illustration of an **"adaptation."**

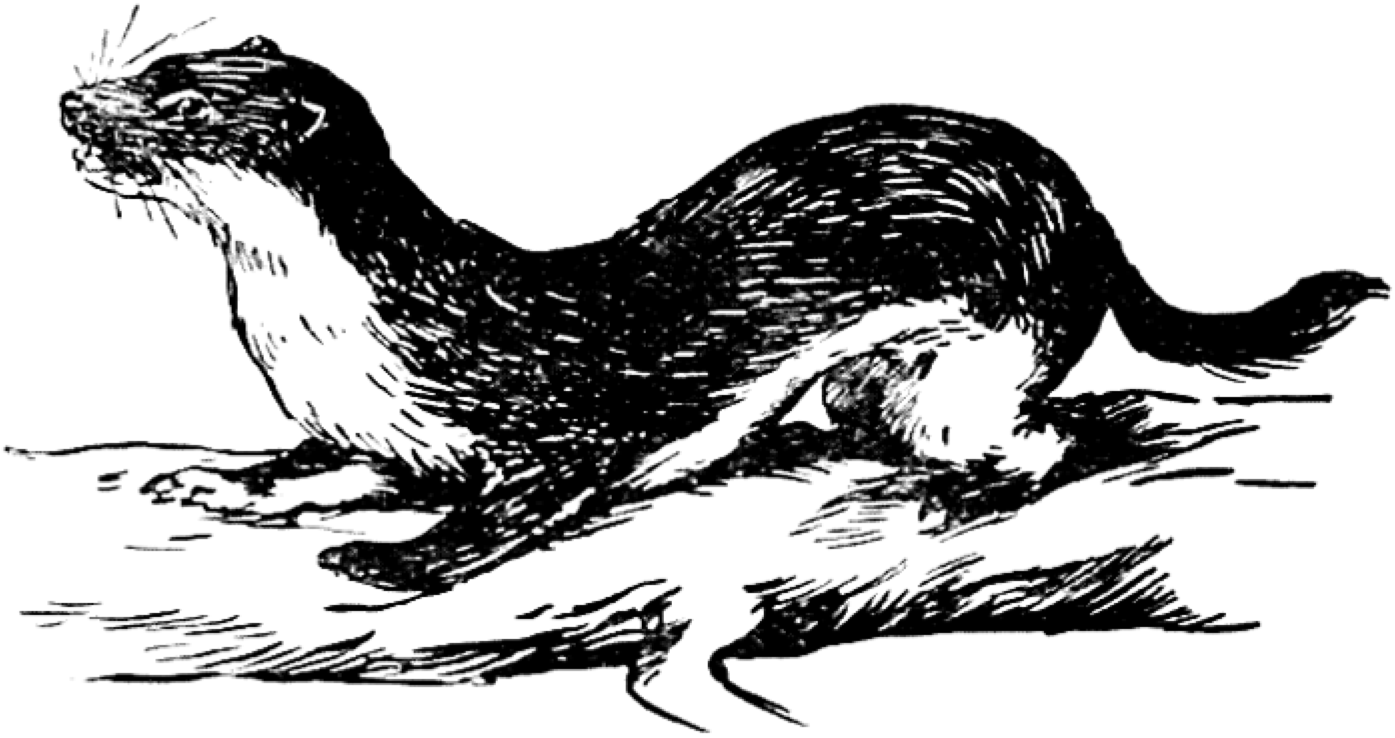

Fig. 46.—A Weasel. Compare the shape of its body with that of a Mole.

Fur.—Now look next at its fur. As we pass the creature through our fingers, it feels delicately soft and almost oily. This fur has been described as "soapy" to the touch. I wonder if you can tell the value to the mole of fur of this particular kind? Although the mole's fur is continually rubbing against the soil, so long as the latter is dry it does not adhere. The fur remains clean and remarkably free from grit.

Notice, too, that the fur seems to stand out straight, and not to lie in any particular direction. Fur of this kind is said to be without "set." Take the mole in your hand and rub the fur backward and forward. The fur you see does not ruffle as a cat's would do if you treated it like this. I think you will understand that if the fur of the mole had a "set" that it would constantly be getting ruffled. It is interesting to notice that the shape of the hairs composing the fur is altogether peculiar. Remove a few and look at them on a sheet of paper with a good magnifier. Then draw them on your note-book (Fig. 47).

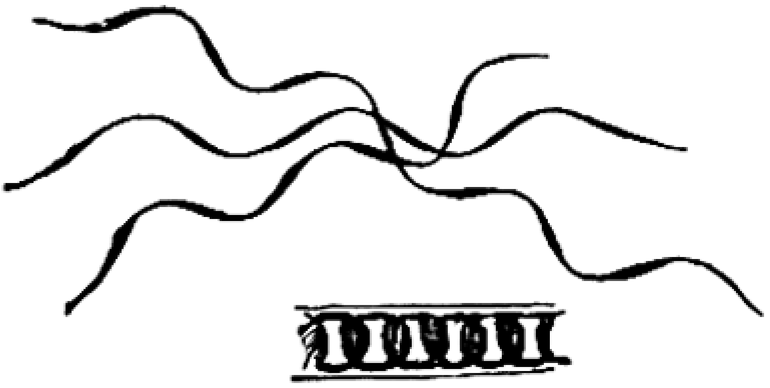
Fig. 47.—Hairs of Mole, with a small part magnified.

Drawings.—Now you must make a drawing of the body of the mole, but you must do it bit by bit. Begin by drawing **the head,** and, in doing so, look closely at the head itself. You see it tapers quite suddenly in front of the body. No neck is visible externally. We shall see in a little what has happened here. Now draw the **snout.** It is fairly long, tapering evenly. You can feel it is rather firm. There is, in fact, a special bone in the mole's snout which other mammals do not have. The mole does not bore with its snout, but no doubt the snout is often used to push the earth aside, and it is interesting to find that there is a special supporting bone present in it.

Where is the **mouth?** On the under side, you see, some little distance from the tip. You must make a special sketch of the under side to show the position of the mouth. Notice the shape. It is like a long narrow U, the lips are thin, and that of the upper jaw forms a close **covering to the teeth.** What is the use of this peculiar upper lip? Do you not see how useful it will be acting as a kind of curtain keeping out grit? Can you see its teeth? They are small, but closely set and sharply pointed. Notice the **canines**—the so-called "eye teeth." They are longer than the others.

Do you know what is the **chief diet** of the mole? It consists of **earthworms**. I think that it feeds on other things too, at times, such as "**leather jackets**" (crane-fly larvae) These have been found in the mole's stomach.

The mole belongs to the same group of animals as the hedgehog and the shrew. They are called **Insectivora,** that is, "insect eaters." Their teeth have many sharp points with which to break the hard skins of insects. But although the mole feeds mainly on worms, this kind of teeth is excellently suited for holding worms which twist about a great deal. And you ought to see the mole's **tongue**, which is long and narrow like a strap. It, too, is useful in dealing with the wriggling worms.

Around the snout are many stiff projecting hairs. These are sensitive, they help the mole to feel all the more delicately. This is very necessary, since the mole's sense of sight is not very good.

The Mole's Eyes.—Did you know that the mole has got eyes? Many people think moles are blind. The eyes are very small, and are completely hidden by the fur. You can understand why that is so. The fur keeps the soil from hurting them. You must blow aside the fur on the side of the head, keeping a sharp look out, when you will catch a glimpse of the very small black specks like small pin heads. These are the mole's eyes.

Moles do not see very well. This is not so much because their eyes are small, but because they are imperfect eyes. But this does not matter very much, as the mole lives practically its whole life in the dark.

Hearing.—If the mole cannot see well it can hear acutely. It has got a pair of ears, but you will not see them standing out upon its head. In all these things you see the mole is different from animals which live above ground. We are finding, are we not, that its **body is made to suit the place it lives in.** Ear lobes standing out upon the head would be apt to get filled with soil, which would annoy the animal. But besides this they would be just as unnecessary as clear, far-seeing eyes would be. Sounds reach the mole not through the air, but through the soil chiefly.

Their ears—that is, the organs they hear by—are placed deep in the head, at the end of a long narrow tube. If you blow aside the fur again, this time near the back of the head, you will see the opening of this tube. If you pass in a pin—head end first—you will find it goes down quite a long way. Thus you see how well this delicate part is protected from contact with the loose soil.

I am sure they are very sensitive to movements above ground or in the soil. When you draw the mole's head be sure and put in the eyes and the ear-hole. They can be made to look as if the fur was turned aside to show them.

The Limbs.—Although the mole runs about even quickly in its tunnels, there is another very important use it makes of its limbs, especially the fore limbs. What is that? Digging, of course. Look at these fore limbs (Fig. 45). Do they not seem very short? So they are, although not so short as they look. They are far forward, so that when extended they can scrape the ground in front of the snout. Then the paws are turned outward instead of downward, so that they can throw the earth back away from the body. And the paw is very broad, its claws are long and squarely cut, not pointed, and if you feel the side of the palm you will feel a curved bone, which not only strengthens this part but gives it greater width (Sickle bone). (Fig. 48.)

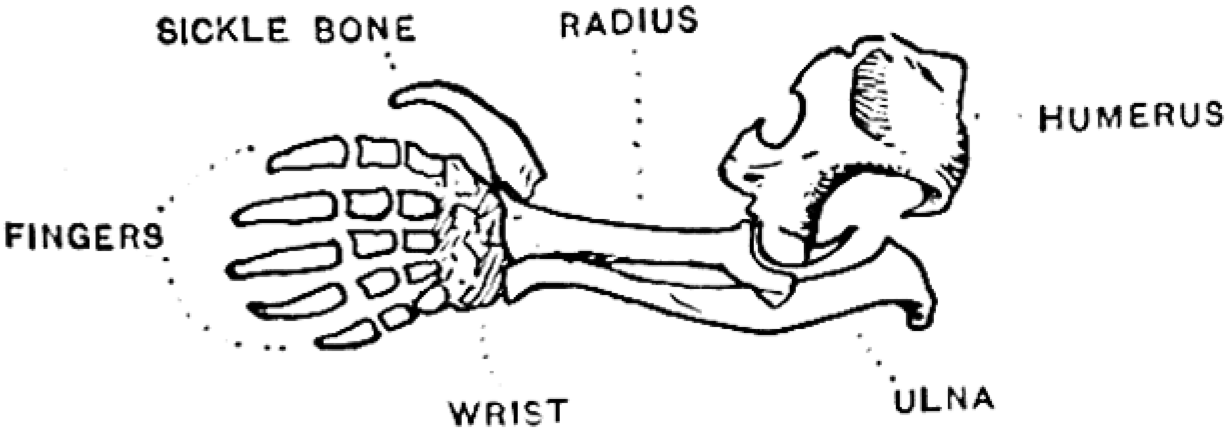

Fig. 48.—Fore limb of Mole.

The work is very hard and difficult, and this limb is fitted in a very special way for it, even in many ways we have not noticed at all. The bones, for example, are of special form to suit the work of the limb. You must look very carefully at this part, and make a drawing of it also. The bones are the same as in the fore limbs of other mammals but altered in shape to suit the mole's work. You may feel some of these through the skin. Your teacher might draw them upon the blackboard and show you by comparing with your own arm where the chief differences lie. It is interesting to **compare it with the hind paw,** which is quite slender and weak-looking. But it is suited, after its own fashion, to its work also, which is running, and not digging.

Revision.—Sum up the principal ways in which this creature's body is adapted to the special life which the animal leads.

ZOOLOGICAL CHARACTERS AND CLASSIFICATION

of Animals dealt with in the foregoing Chapter.

The animals dealt with in this section are all quite common and require brief treatment only. The purpose of the present section is best served by dealing with them in ascending order in the zoological series.

Insecta.

The gnat (*Culex pipiens*) belongs to the Order *Diptera*, *i.e.* it is a true fly. It has slender, moderately long feelers (antennae), a character which places it in the division Nematocera or "thread-horned" flies. It is a member of a very large family (Culicidæ) many of the species of which are blood-suckers, *e.g.* those popularly termed mosquitoes. They are world wide in their distribution. The commonest species in Britain is probably *Culex pipiens*, the female of which is capable of sucking blood and habitually does so. The male feeds on plant juices. The habit of passing the early stages of the life-history in water is of course—as in all aquatic insects—secondarily acquired.

Pisces.

The eel (*Anguilla vulgaris*). The eel is a member of the group of fishes with skeleton entirely bony, viz. *Teleostei*. It belongs to the subdivision with open air-bladders, *i.e.* the air-bladder communicates with the gullet. Other fishes similarly constituted are salmon and herring. The cod, on the other hand, has a closed air-bladder, without duct. From a consideration of the life-history of the eel we may conclude that it is a deep-sea fish.

Amphibia.

The frog (*Rana temporaria*) and toad (*Bufo vulgaris*) are familiar representatives of the subdivision of tail-less Amphibia—*Anura*. The characters of the Amphibia are given on p. 451. The common smooth newt (*Molge vulgaris*) belongs, as the presence of a tail indicates, to the subdivision *Caudata* or *Urodela*.

Aves.

Skylark (*Alauda arvensis*), swallow (*Hirundo rustica*), house martin (*Chelidon urbica*), sand martin (*Cotile riparia*) belong to the Order *Passeres* or perching birds.

Cuckoo (*Cuculus canorus*) and swift (*Cypselus apus*) are classified amongst the *Picariae*, an Order which includes the wood-peckers, kingfisher, and nightjar.

The lapwing (*Vanellus cristatus*) is a member of the family of plovers, in the Order *Limicolae*, which includes curlew, sandpiper, etc.

Mammalia.

The mole (*Talpa europaea*) is the only member of this class dealt with in this section. It belongs to the Order Insectivora, the members of which have teeth with more or less pointed tubercles adapted to an insect diet. The other British members of this Order are the hedgehog (p. 178) and the shrews.

QUESTIONS ON CHAPTER II.

(Spring: Animal Studies.)

1. What difference is there in the appearance of frogs' and toads' spawn? What parts are visible to the naked eye in each at a quite early stage?

2. What happens to frogs' spawn soon after it is shed?

3. State the chief uses of the jelly around frogs' eggs.

4. What advantage is there to a frog's egg in growing rapidly in the early stages? What is the use of the yolk in the egg?

5. Why does a tadpole get a tail before it gets a mouth? How does it breathe in the first stage of its existence? Draw a tadpole at this stage.

6. Describe the distinctive features of a tadpole in the second stage. What becomes of the external gills?

7. Compare a toad and frog as regards their appearance, movements on land and water, feeding, and general habits.

8. Describe the movements of a newt on land and in water. On what do newts feed?

9. Draw a larval gnat in a resting position in water.

10. How does a larval gnat descend in water, and how does it rise? Do you think a larval gnat is heavier or lighter than water?

11. What is a young gnat doing whilst hanging at the surface of the water?

12. Describe a simple experiment to show the properties of the surface film.

13. What happens when a larval gnat grows too big for its skin?

14. State what you know as to the differences in appearance and habits in the larva and pupa of the gnat.

15. Why do the pupae of gnats rest at the surface of the water?

16. The pupae of most insects are inactive, those of the gnat are active. Can you tell why?

17. State three remarkable things about the song of the lark.

18. Give a general description of a lark. Where does it build its nest? Describe it.

19. Give an account of the protective behaviour of lapwings.

20. Explain in what way lapwings are useful birds.

21. Write an account of the habits of the cuckoo.

22. When do the swallows usually arrive in this country? Where do they come from? Explain if you can—in general terms—why birds come and go regularly between two countries.

23. Describe the shape and general appearance of a swallow. What is the nature of its food?

24. Compare a swallow with a house-martin as regards its appearance, nest, and eggs. How can one distinguish them in flight?

25. Describe the general appearance of the swift as you see it flying overhead. Describe its note. Upon what kind of diet do swifts live?

26. What are elvers? Describe their journeyings.

27. What are yellow eels and silver eels?

28. Show by reference to the shape of a mole what is meant by the term "adaptation."

29. Upon what do moles feed? Write a short note upon their sight and hearing.

30. Make a drawing of a mole's fore limb.

CHAPTER III.

PLANT STUDIES IN SUMMER.

LESSON XXI.

SOME COMMON POD-BEARING FLOWERS (Leguminosae).

[Both early in the year and throughout the summer leguminous plants are readily found. A series of these might suitably be examined from the point of view of their arrangements for the attraction of insect visitors and their effective pollination. The points suggested below are selected for this purpose and are intended to serve for several lessons. The vegetative parts and fruits of the respective plants are not dealt with, except in the case of white clover.]

Recognition of Common Examples.—Pod-bearing or pea-flower plants are easily recognised. They are sometimes called butterfly flowers, because of the fancied resemblance of all those occurring in our country to butterflies with outspread wings. Let us mention some of the flowers of this kind whose names we know. (The teacher should have examples of several species.) We are familiar with the **gorse,** which is in flower through most of the year, and with the **broom**—both of these have large yellow flowers. The **laburnum** is another beautiful yellow flower of this kind. **Lady's fingers, bird's-foot trefoil,** and **meadow vetchling** are still others of yellow colour. Then there are **clovers,** red and white, **lupins,** and **rest harrow, vetches, bean** and **pea**

flowers, of various colours, as well as numerous others. You must spend some time looking at these and making sure you will know them again.

General Attractions.—When we think of all these flowers, or look at a collection of them, we notice that they have various attractions. The single flowers are of striking shape, they are **brightly coloured,** and sometimes quite large. In many cases they are grouped in clusters, such as the laburnum or clover. Many of them are **sweetly scented,** and possess **nectar,** and all yield **abundance of pollen.**

What is the special meaning of these attractions? They are **invitations to insects.** That is quite clear. Are all insects welcome to these flowers? No; they are not. We shall look particularly at a few, and before we are done you will see that there are insects which we may describe as **invited guests,** others which are uninvited, because means are provided for keeping them out, and that amongst both of these classes, strangely enough, there are thieves or robbers, which take honey and give no service in return.

Examination of a Flower of Broom (*Sarothamnus scoparius*).—Let us look first at a single flower of the broom in order that we may become familiar with the various parts of pea-like flowers in general. Observe first its size and colour making it readily noticeable. Recall here the entire plant usually so rich in blossoms that it is most conspicuous and attractive.

Note next the individual parts. There is a united circlet of small sepals firmly grasping the inner parts (**gamosepalous calyx**) and holding them erect. On the side nearest to the branch there is one large petal. In the unopened flower you can see that this encloses the other parts, but in the expanded flower it is spreading and is the most conspicuous part. For this reason it is called the **standard.** It is used by bees as a support; they press their heads against it while they are probing in the flower and thus steady themselves.

In the broom you can see streaks or lines pointing towards the centre of the flower. Such lines upon flowers usually point in the direction in which honey is to be found, and are hence called **honey guides.** What other plant have you seen with honey guides? The strange thing is that there is no honey in the broom, so that these lines deceive in this case.

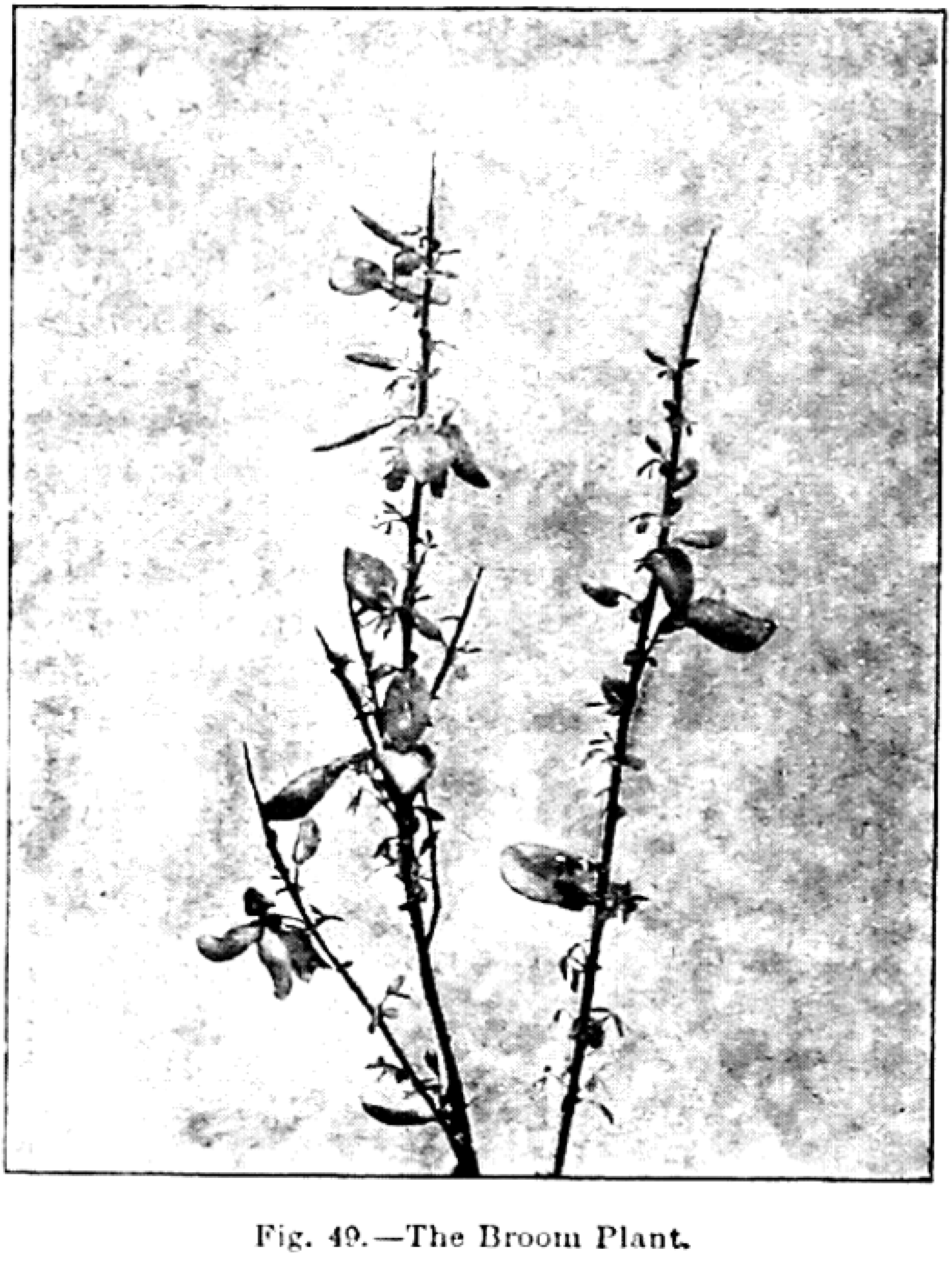

Fig. 49.—The Broom Plant.

At the sides of the standard are the **wings** or **alae.** These serve as a place upon which visiting bees alight. Hold the flower in your left hand and press these down gently with the thumb and first finger of your right hand. Do they bend down alone? No, they carry the petal which lies between them downward also.

This petal is termed the **keel or carina.** Wings and keel are joined together near their base by interlocking folds. Examine these closely, and imitate the action of a bee pressing down upon the flower. Do it gently at first. What is disclosed from within the folded carina? First there appear five short stamens. These strike the under side of the bee, scattering pollen upon it. Continued pressure next causes the long coiled style to spring out rather violently, hitting the bee this time upon the back with its tip and scattering pollen by means of its flattened part from the inside of the carina, also upon the bee's back. At the same time the five long stamens are released and these spring out from the carina also.

Press down the wings more firmly now until the style and whole of the stamens are released. Examine carefully all the parts disclosed. Notice that the stamens are united into a tube at their base, enclosing the ovary, that the style is long and spirally coiled, and that its last portion is flattened. Compare what you find here with the corresponding parts in a pea flower (Fig. 50).

Go over the whole flower carefully until you know all the parts and understand their working.

Make drawings of the flower before and after it is exploded, of the separated wings, and of the tube of stamens.

It is most important that drawings be made.

Object of the Mechanism.—Let us now inquire as to the meaning of these arrangements.

Since there is no nectar, what do the bees visit the flowers for? In this case it is the pollen, of which there is generally an abundance.

The visit of bees is of advantage to the flower because cross-pollination results. Have you noticed at what stage this happens? It is **when the stigma strikes the bee's back.** You remember how the pollen is swept on to the back of the visitor by the flattened end of the style, so that when next the insect visits a fresh flower the stigma receives some of this pollen as it strikes.

When once a flower has been opened by the action of an insect it remains open. It is not easily opened, indeed only the heavier **humble bees** can do it readily. Hive bees do so only with some effort. These are the invited guests. Smaller and lighter insects cannot with the same certainty bring about cross-pollination, and these are kept out. But after the flower is opened and pollinated other insects are free to visit it. Some which you may see upon the opened flowers are smaller bees, hover-flies (p. 288) and beetles, all devouring pollen. Examine a broom plant and discover the flowers which have been opened by insects.

The Flower of the Gorse (*Ulex europaeus*).—In general the parts of this flower are similar to those of the broom. You will find if you examine the flowers that when opened by pressure upon the wings they remain open just as does the broom. But the action upon the visiting insect is simpler. Try the flower and you will find that it is easier to open, therefore **lighter insects can obtain the pollen.** The style is not curled and strikes the bee on the under side, as also do the anthers.

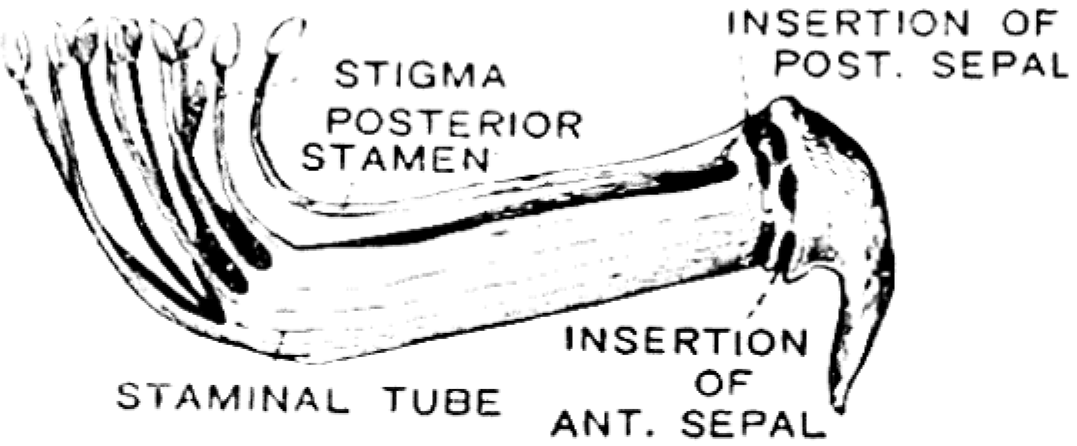

Fig. 50.—Stamens and Pistil of Pea Flower.
Here one stamen is free, the other nine are united. There is nectar in this flower.

Cross-pollinating is thus done by the under side of a bee which has been already dusted with pollen being brushed by the stigma of another flower during a subsequent visit. There is no nectar, although bees may sometimes be seen searching for it.

Examine a pea flower in detail and compare its parts and their working with those of the foregoing (Figs. 50 and 51). Draw the tube of stamens and stigma.

Summary.—A study of these flowers makes more evident the importance of cross-pollination amongst flowering plants. Although self-pollination is generally effective, it is clear that cross-pollination is more so. Can you state briefly the advantages of the latter? Experiments have proved that from it more vigorous seed results, and further that in the resulting plants there is more variety in detail. This latter is very important, because, as you will gradually discover the longer you study living things, it is out of such varieties that **new and better adapted types arise.**

LESSON XXII.

WHITE CLOVER (*Trifolium repens*).

[Each pupil should be supplied with a clover plant. There is material for at least two lessons in the following.]

This common flower, though small, has a number of important peculiarities. We are already familiar with the general characters of pod-bearers or pea flowers. Let us see if we can discover what the particular features of the clover plant are.

The Inflorescence.—In clovers the flowers are clustered together in globular heads called **capitula.** You have in your hand such a flower-cluster. Look at it and recognise the individual flowers. Do the flowers arise directly from the main stalk? No, you can see they are placed each upon a short stalk of its own, and you can move the flower freely upon it.

Note the advantage of having these small flowers clustered in this way. It is very important that they should be found by bees, and they are of course **more easily seen** when grouped in this way. Another rather important point is that the **time of the bees is saved** in visiting the clustered flowers.

The Visits of Bees.—How do the bees find the clover first of all? It is not by sight, but **by scent.** Do you feel the smell of the clover flowers? What does it suggest to you? Is it not a smell like that of honey? The bees smell this and are guided towards the flowers by it. Then, when they are closer, they see the white clusters of flowers. Of course you know that a bee's visit is profitable to the flower as well as to the bee. There is abundant nectar in the clover flowers. You may taste it by sucking the ends of a few of them. The bees come and suck this and, in doing so, carry pollen on their bodies from flower to flower, pollinating the stigmas and thus forming seed.

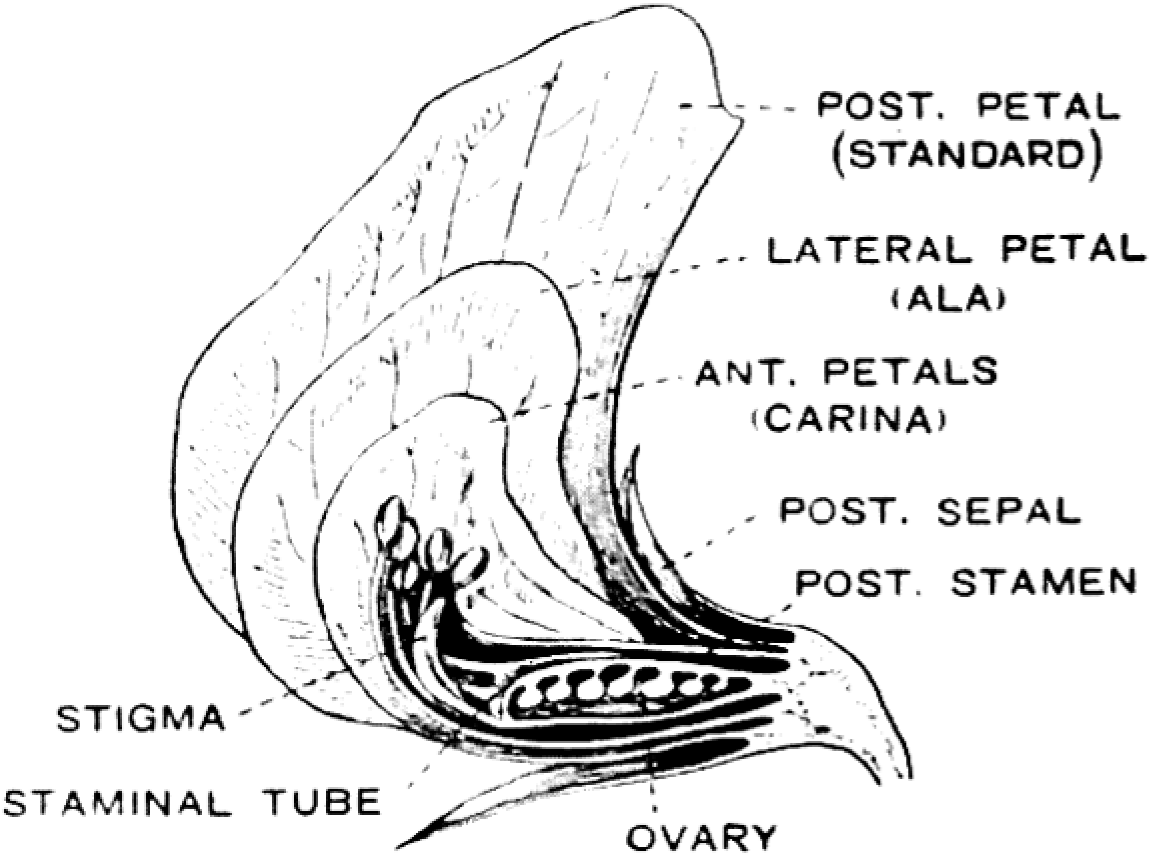

Fig. 51.—Section of the Pea Flower.
(The structure of the Bean Flower is practically the same.)

If a clover flower be visited by a bee and it should happen that pollination does not take place—as is of course possible—what happens? The flower remains as before, ready for another insect visit. We noted, for example, that when broom flowers are visited by bees, their parts are disarranged, the wings are separated from the keel and the keel itself torn downward. This is not the case with clover.

What happens is this. The bee alights on the flower-head, fixes on a particular flower, holding on to the wings, and pressing its head against the standard pushes its proboscis down the tube and sucks the nectar. When it withdraws itself the wings and keel, which have meantime been pressed downward out of the way, **return to their former place** and are capable of being similarly treated a number of times without the flower parts being disarranged.

Fig. 52.—White Clover.

It is a pity the clover flower is so small, because that makes it difficult for you to see the very firm way in which its parts are held together. But you should perform the following simple experiment, which you will find worth doing.

Exercise.—Remove a clover flower, laying it upon the page of your book, letting it lie upon the back of the standard. Take a pin in each hand, and, steadying the flower against the paper with the pin held in the left hand, gently raise upward and backward the remaining parts of the flower (wings and keel and enclosed parts) until they separate from the standard. Now look at the separated parts with a lens.

You will find the stigma attached to the pod-shaped ovary, a single stamen by itself, and the remaining nine stamens united together. (Compare the flower of the pea.) Also you will find—and this is the special point of interest at present—that the wings and keel have not been separated from each other. You may have succeeded in splitting the keel in two, but to each half of it there adheres the wing of that side. Wings and keel are so firmly interlocked that when bees bear them down as they force their way into the flowers, they simply return to their former place when the pressure is relieved.

(If this exercise should prove too difficult for the pupils, the teacher should perform it and exhibit the parts described.)

Changes after Pollination.—When a flower has been fully pollinated, however, it **stops secreting nectar,** and the **corolla withers.** Look for clover heads which have been partly pollinated. Can you distinguish those in which the process has taken place? Yes, not only by the browning of the corolla which has taken place, but by something else. What is that? Do you see the **change of position** which the flowers undergo as they proceed to form seed? The fertilised flowers **bend backward** upon their short stalks out of the way, and only the unpollinated flowers stand up. This arrangement again is useful, for the **bees see at once the flowers worth visiting,** and they can get at them all the easier that they are standing up by themselves.

Other Parts of the Clover Plant and their Uses.—Like many other plants, clover is not dependent upon seeds alone as a means of multiplying. Its stems creep along just below the ground, branching and sending out roots at the joints (**nodes**) into the soil, and leaves and flowers above ground. Cutting the stem does not therefore destroy a plant. You should dig up a piece of a clover plant so that you may see something of the extent to which it spreads in this way. Notice the following parts: long branched roots, upon which you may find small growths, "**tubercles,**" of great importance to the plant; leaves arising in two rows at the sides of the stem; the bending of the leaf-base, so that the leaf assumes an erect position.

You must now try to think of the value of these things to the clover plant.

1. The runners serve as an additional and very important means of multiplying.

2. The *long* roots enable the plant to draw raw food materials (mineral substances) from the lower regions of the soil not reached by many other plants.

3. The "tubercles" enable the plant to draw upon free nitrogen in the soil.

4. The power of movement in the leaf-base enables the plant to place its leaves in the best position for obtaining light.

The Clover Leaf.—Examine an entire leaf. Is it simple or compound? Compound (p. 142). How many leaflets are there? Three. Draw a leaf carefully putting in all details, then describe it in words. What is the shape of the leaflet? Narrow at the base, rounded broadly at the free end. Note how well this shape enables the three leaflets to fit into each other in the expanded leaf. Note the toothed margin, notched lip, marked midrib, and clear veining. Compared to the size of the leaflets, is the leaf-stalk long or short? Generally long, but it varies with the situation in which the clover is growing. What is this an adaptation to? Examine quite young leaves. How are the leaflets folded? Each one separately along the middle line so that they lie alongside each other. Which surface is exposed? The under side.

Movements.—Have you seen the clover leaflets "asleep"? If not you must look at the clover plants in the evening. How do the leaflets dispose themselves when they sleep? The two lateral ones droop, moving inward so that their upper surfaces face each other and are in actual contact. The third leaflet bends downward over these, folding in along its midrib with its upper surface downward, covering the others in a roof-like manner. Examine the leaflets with a lens, and notice the "joints"—wrinkled-looking—where the actual moving of the leaflet takes place.

Can you think what is the meaning of these movements? You observe how the upper surfaces are more especially protected. It appears that most (though not all) of the giving off of water vapour from clover (**transpiration**) goes on by the upper surface, and the sleep arrangements tend to prevent it going on to excess. They also keep the plants warmer. Experiments have proved these things. Clover appears to be a plant which is specially sensitive to the loss of moisture or warmth, and hence these **"sleep" movements are protective.**

Do you notice the white crescent-shaped patch upon the upper surface of the clover leaflet? This is very distinctive, can you tell what it is due to?

An Exercise.—Perform the following simple experiment. Dip some clover leaves in boiling water, and leave for a few minutes. What happens? Minute air bubbles rise from both surfaces of the leaf, it becomes a darker green and the white patches disappear. Hold the leaflets up to the light and you can still see the paler areas. The white patches are produced by the presence of air in spaces in the leaf. The boiling water drives out the air. We know that air spaces are distributed generally in the inner regions of leaves—mostly nearer the under side (p. 145). Here they are larger than usual and nearer the upper side. What the special use of them to the clover plant may be is not very clear.

Trace the leaf-stalk to its base. Notice the membranous **stipules** clasping the stem at their bases. Stipules are a common character of the leaves of leguminous plants. Compound leaves are also characteristic.

When you have drawn the clover leaf recount the more interesting things you have learned about it.

For the teacher who desires further detailed studies of papilionaceous flowers, the following table (adapted from Knuth's *Handbook of Flower Pollination*) of the arrangements in relation to pollination will be found useful. In addition to the flowers already studied, the examination of those of bird's-foot trefoil and pea might be suitably undertaken as giving a representative series.

TYPES OF FLOWER MECHANISM IN PAPILIONACEAE

(after Delpino).

Simple Valvular Arrangement.

Stamens and pistil project from the carina as long as the pressure of the bee continues, and then return to their former position. Such flowers thus permit of a number of effective visits.

A. With Nectar.

Melilot (*Melilotus*), clover (*Trifolium*), sainfoin (*Onobrychis*), milk vetch (*Astragalus*), bird's foot (*Ornithopus*), French honeysuckle (*Hedysarum*).

B. Enclosed sap reached by boring.

Laburnum (*Cytisus*).

Explosive Arrangement.

Stamens and pistil suddenly spring out of the carina under the pressure of the bee. The flower is thus rendered incapable of further effective visits.

A. With Nectar.

Medick (*Medicago*).

B. No Nectar.

(*a*) The ventral surface of the bee comes in contact with the pollen and stigma: petty whin (*Genista*); gorse (*Ulex*).

(*b*) The bee is struck on the back by the pollen and stigma: broom (*Sarothamnus*).

Piston Arrangement.

The thickened ends of the anther filaments press out the pollen in successive portions from the tip of the carina. Several insect visits are necessary for pollination.

A. With Nectar.

Bird's-foot trefoil (*Lotus*), lady's fingers (*Anthyllis*), horse-shoe vetch (*Hippocrepis*).

B. No Nectar.

Rest harrow (*Ononis*), lupin (*Lupinus*).

Brush Arrangement.

A tuft of hairs on the style sweeps the pollen out from the tip of the carina. Here again repeated insect visits are usually necessary for pollination.

A. The tip of the style is straight.

Peas and vetchlings (*Lathyrus*) (*Pisum*), vetches (*Vicia*).

B. The tip of the style is coiled.

Bean (*Phaseolus*).

LESSON XXIII.

THE DANDELION (*Taraxacum dens leonis*).

[Flowers should be given to the children for examination, and at least one good specimen of the entire plant should be dug up and exhibited.]

A Common Plant.—The dandelion is commonly regarded as one of the "meanest flowers that blow." It is true it is a very familiar plant, but that is a good reason why we should not pass it by unnoticed. I think we shall find it not uninteresting and that we may learn some important things from it. We shall certainly not neglect it because it is common—rather let us **seek the reason why it is so.**

Familiar Features.—The parts we know best are, of course, those above ground. The yellow flower head, its hollow pinkish stalk with bitter taste and white juice which flows from the cut or broken edge, the leaves in a rosette close to the ground, their distinctive shape with deep sharp-edged backwardly-turned notches, which have given the plant its common name—dandelion (*dens leonis* = lion's tooth). All these we know. There are several common yellow flowers like the dandelion, but which are to be clearly distinguished from it, because none of them combine *all* those features we have just named. Here are some of the flowers which slightly resemble dandelions. How many of them do you know? Can you point out any clear differences between any or all of them and dandelions?—

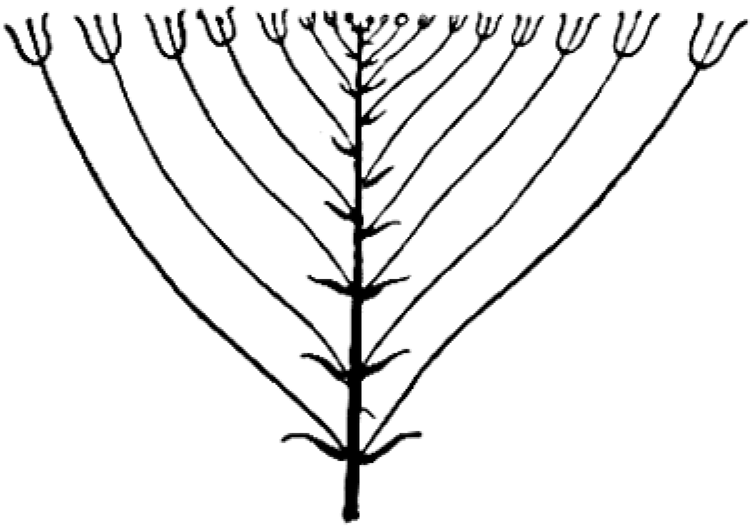

Fig. 53.—A Corymb. By reduction of the main axis and shortening of the individual flower stalks a capitulum type of inflorescence is produced.

Cat's ear, sow thistle, hawk's beard, hawkweed, coltsfoot and a number of others.

I think you will do that very much better after you have looked more particularly at the flower before you.

The Flower Head.—A dandelion is not a single large flower, but a whole cluster of small ones gathered together forming what is called a "head" or **capitulum.** What other plant do you know where flowers are grouped in "heads"? The head of the flower stalk is just a flowering stem which, instead of being lengthened out and having all its flowers with their bracts distributed over it, is compressed or **reduced into a flat top,** upon which all the small flowers are gathered closely together and their **bracts are arranged in circles around the outside.** (The teacher should illustrate by means of a diagram how the capitulum may be produced from a more open form of inflorescence. See Fig. 53.) Look, and you will see this for yourselves. The narrow green parts around the outside of the flower head are the bracts, and each yellow strap-like part is the most conspicuous portion of each separate flower. There are between 100 and 200 of these.

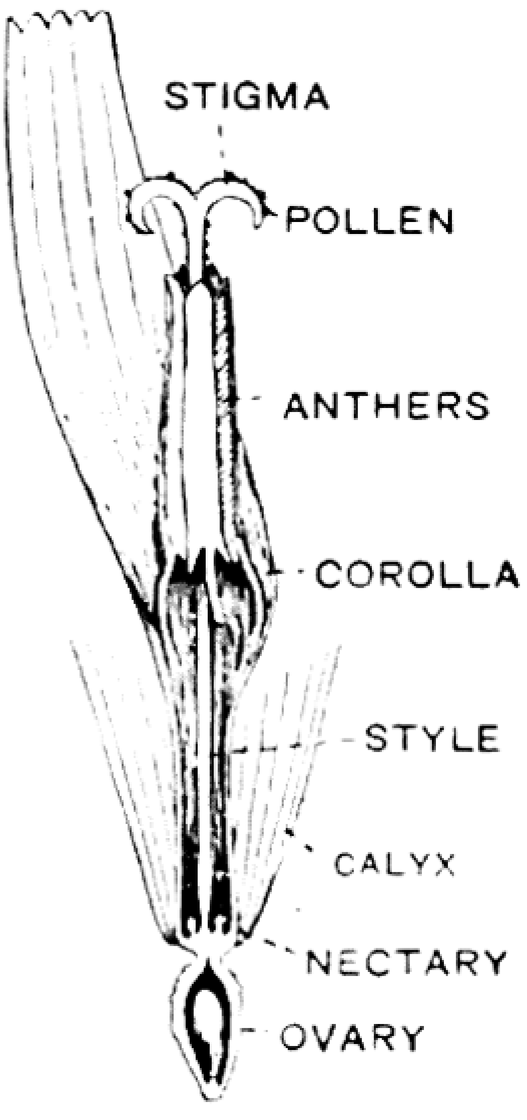

Fig. 54.—Floret of Dandelion. Basal part cut in sections.

Let us each carefully remove a **floret,** as the single flower is termed. Lay it gently upon the page of your book and examine it closely. Use a pocket lens. As we look at it we shall draw it carefully (Fig. 54).

Perhaps you thought the yellow strap-like parts were petals? Well, that is quite right so far, although they are not simple ones. Do you see the fine lines running along straight to the end? Is the edge of this yellow strap even or notched? The lines and notches mark the five petals of a single flower, here united into one and spread out at their free end, although you will note they are united into a tube at the base. This flat part then is really the **corolla of the floret.** Now we must find the other parts.

Around the outside of the corolla, down at the base, is a circlet of fine **soft hairs**—this is the **calyx.** In front of the corolla you will now find the pistil with its **stigma.** What is the appearance of this last? It is spread out in two flat coils from the top of the pistil. If you compare a few florets you will find that they differ in the amount of coiling—this depends on their age and whether they have been pollinated or not. The florets are not all of the same age, those nearest the outside are the older. How can you tell this?

There are five **stamens** united closely around the pistil, which latter is connected with an ovary situated below the calyx.

Examination of the Pistil.—Let us return to the pistil for a moment. Do you observe that it is not smooth below the stigma, but carries a large number of hairs pointing obliquely upward? These hairs are very important, and if you look at a few florets of different ages you will readily understand their use. Do you see that the style as it grows pushes its way up the centre of the ring formed by the stamens? At this stage the stigma is not exposed, but the stamens may be shedding pollen. These hairs brush through the pollen and carry some of it up adhering to their surface. Later the stigma unfolds, its two parts coil round, and its pollen-receiving surface is now exposed.

Pollination.—These flower heads are visited by a great many insects of different kinds—beetles, flies, bees, saw-flies, butterflies—some seeking pollen and others nectar, and they are very useful in depositing pollen upon the stigmas and in this way bringing about cross-pollination.

But although this is so, it may happen that some stigmas miss receiving pollen, or the weather may be very bad and insect visits few, with the same result. In such cases the **use of these hairs** upon the pistil becomes very clear. Self-pollination is always better than none, and the unpollinated stigma continues to coil backward until some part of its surface touches the pollen adhering to the pistil hairs. Pollination is effected and the single ovule in the ovary will in due time become a seed.

Go over your drawing carefully and be sure all the important parts are clearly marked, and be sure you understand the ways in which the flower may be pollinated.

Opening and Closing Movements.—Have you noticed that dandelions open in sunshine, and close in the later part of the day and during the night? They also remain closed in bad weather. When they are closed the bracts, of which you will notice there are two sets, press inward covering up the florets. What purpose do these movements serve? One important thing they do is to protect the pollen from wet, and nothing is lost to the flower when visiting insects are not abroad.

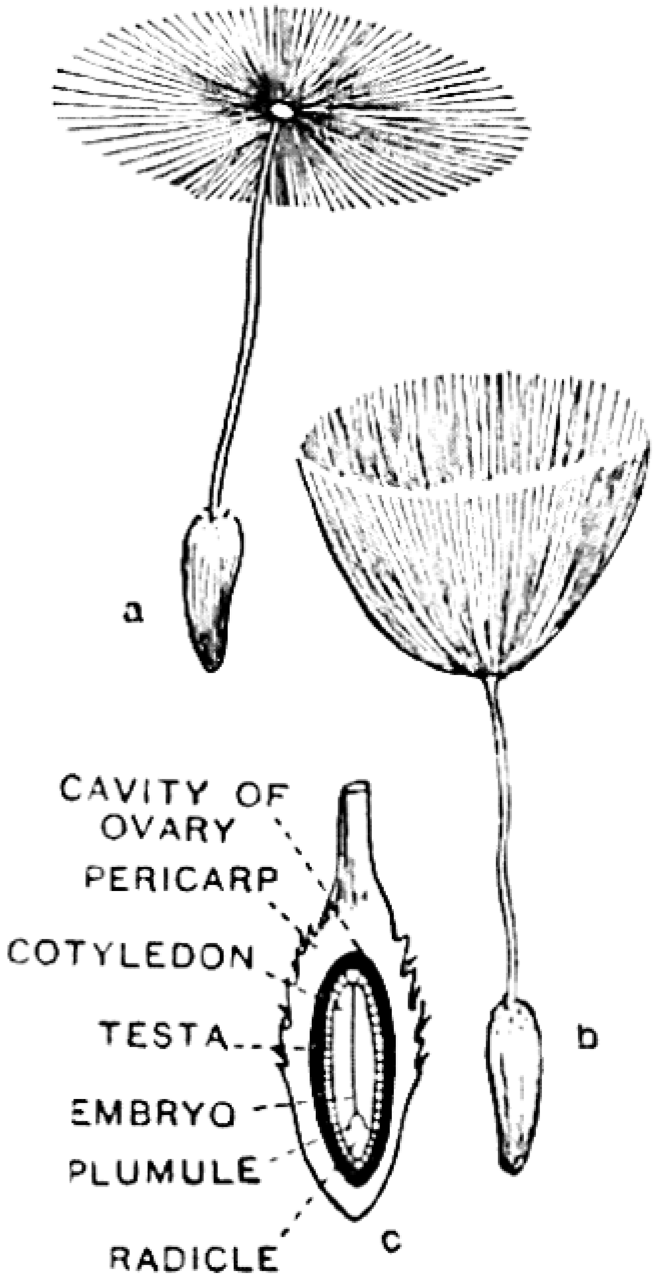

Fig. 55.—Fruit of Dandelion.
(*a*) With Calyx expanded, (*b*) with Calyx closed, (*c*) Fruit in section, showing the several parts.

Advantages of Capitula.—What is the benefit of having the flowers grouped together in heads? First of all the small flowers are in this way made more conspicuous to insects, secondly they are much more likely to be cross-pollinated — which is always best—than were they placed singly. The best proof that this kind of arrangement is a good one is that plants of this habit (Compositae) are far more numerous than those of any other kind.

The Ripe Fruit.—Some of our dandelion plants have got beyond the flower. Here are some in the fruiting stage. The yellow corollas, having done their work, have withered away, so has the upper part of the pistil. The calyx, however, remains. What change has come over it? It has grown up from the ovary, having formed a long stalk. Attached to the base of the stalk is the fruit—**what is commonly called the seed.** But the seed is within this. (Fig. 55.) You know the use of the calyx now. You have often helped nature by blowing these tiny "fairy arrows" into the air. Let us blow these and watch them floating away in the wind. Tennyson has described this very familiar action in *Alymer's Field,* where two children are described as blowing

> "From the tiny pitted target
> What look'd a flight of fairy arrows aim'd
> All at one mark, all hitting."

Compare the fruit and the head of the flower stalk with the descriptions "fairy arrow" and "tiny pitted target."

It is interesting to note how the sun as well as the wind helps to disperse these fruits. Have you observed how, under the warmth of its rays, the ripening heads expand and gently burst the enclosing ring of bracts, spreading out their hairy calyces until the perfect open globe is formed, which is then ready to yield its fruits to the gentlest breeze?

The Leaf.—The leaves of this plant are worth notice. First of all observe their arrangement. They are spread out in a rosette close to the ground. The dandelion in growing this way clears a space as it were for itself. The leaves cut off the light close to the ground so that other plants find it very difficult to get root-hold near it. This gives the roots below ground more room to themselves, and also ensures that the leaves will not be thrown in shadow.

Then notice the shape of the leaves. They are narrower towards the centre than they are further out; this prevents overlapping of parts, and the notches in the leaves permit of a certain amount of fitting-in amongst each other with the same result.

Carefully draw a leaf rosette of the dandelion as an illustration of the competition for light which goes on amongst plants.

The Root.—The dandelion you see has many things in its favour. And these are not all. For below ground there is a strong tap-root, which when cut grows new flower-bearing stems from the cut surface.

How Dandelions are Common.—When do dandelions come into flower? The end of February or beginning of March, and they flower right on to near the end of the year. They are thus hardy plants. They produce large quantities of seed which can germinate readily in fields and by waysides. Their seed is widely distributed by the wind. They are perennial plants, with green leaves all the year, they are adapted to securing a place for themselves, and to ousting others from the region in which they have settled, and when their roots are wounded they can heal readily and grow fresh flowers from the damaged part.

When we have learned all this, have we not discovered, in part at least, how it is that dandelions are common?

(The teacher might here read and explain to the pupils Russell Lowell's fine poem *To the Dandelion.*)

As supplementary lessons, examine some of the following plants, comparing them with regard to flower structure, flower stalk, foliage, stem, roots, and seed distribution :—

Smooth hawk's beard (*Crepis virens*).
Mouse ear hawkweed (*Hieracium pilosella*).
Sow thistle (*Sonchus oleracea*).
Nipplewort (*Lapsana communis*).

LESSON XXIV.

THE DAISY (*Bellis perennis*).

[A specimen for each pupil should be provided. Lenses will help the pupils greatly to see the more minute structures. The exercises in classification will provide material for additional lessons.]

Attractions.—This, the most familiar flower of childhood, is one which continues to have many charms for us in later years. Various poets have sung its praises and have spoken for us what we feel about it. Shakespeare saw the daisies in charming profusion when he wrote:

> "Daisies pied, ...
> Do paint the meadows with delight."

Do we not feel the truth of this when we see them fully opened in the summer sun? Though we have daisies more or less all the year, they are specially one of the charms of early summer.

Examination of the Flower.—Now we shall look at them from another point of view. Here are some complete daisy plants; let us look first at the flower. If you have examined a dandelion in a previous lesson you will not find it difficult to understand the daisy. The first question to be answered by you is whether this is really a single flower or a "head" of flowers.

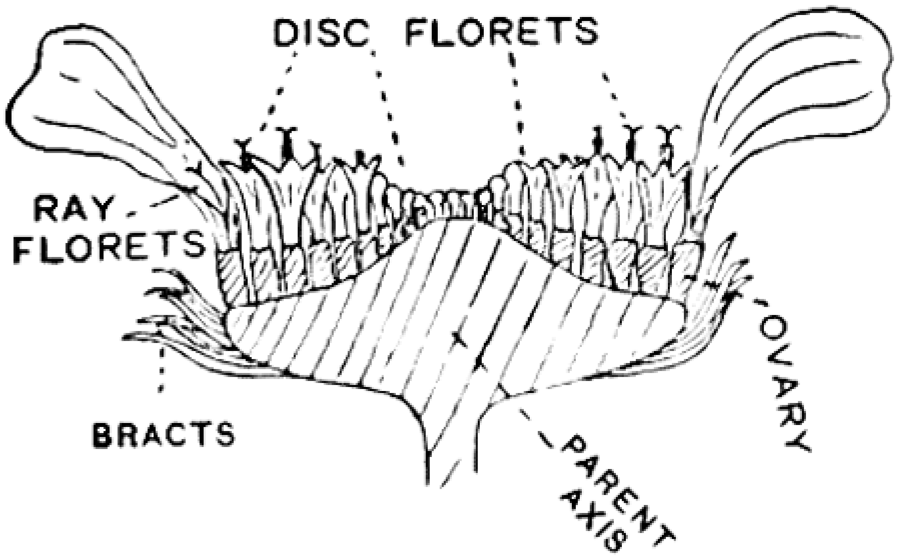

Fig. 56.—Section through the head of a Daisy showing the relations of the various parts.

Examine your specimen closely, and before you answer see that you look in particular at the yellow central part of the daisy, and be sure you see one which is well opened. Knowing what you do about the parts of flowers in general, what do these yellow bodies remind you of? Each is like a **very small bell-shaped flower** in itself.

That is exactly what they are. Let us neglect for a moment the white petal-like parts around the margin. Take a magnifier and look especially at the yellow florets around the margin of the disc. How do they differ in appearance from those at the centre? They are more fully opened. That is right. The florets are not all of the same age, and the youngest ones are in the centre.

Now you might take a sharp knife and cut a daisy in two, slicing right across the top and cutting down to the stalk. Lay out the two halves in front of you so that you can see the cut faces exposing the inside of the daisy head (Fig. 56).

Next make a drawing—let it be at least two inches across—which will show the shape of the head of the flower stalk (parent axis), and a row of florets from side to side upon it. If you represent exactly what the daisy shows, the florets at the margins will be the largest, and they will become gradually smaller towards the centre. Then at each margin you must add one of the white strap-shaped parts as well as a covering of the green enclosing leaves (not sepals, of course, but bracts).

The Disc Florets.—While you are doing this you cannot fail to notice some of the parts of the yellow florets. For example, how many petals are present? Count the tips at the edge of an opened floret. Five. Yes, there are **five petals**. The whole thing is rather small, and it is difficult for you to see everything, but with a lens you should at least manage to see the **short, broad limbs of the stigma,** and perhaps the **pollen-sweeping hairs upon the pistil** just underneath. Remembering what you saw in the dandelion, you will easily understand that here is something very similar, and that the meaning is the same.

Can you explain the use of the hairs below the stigma? What do you find adhering to them? Pollen. Perhaps you will be able to see the **anthers** from which the pollen was brushed.

Do you see any florets from which the style seems to have disappeared? These are **florets which have been**

pollinated. When this takes place the branches of the style are drawn back into the bell of the flower.

The Ray Florets.—Now will you remove entire one of the outer white parts. What does this remind you of? The strap-shaped florets of a dandelion. Quite right. What then is the white portion? The **corolla.** What do you find in front of this corolla? The **style** with its stigmatic branches. That is right. Now can you find any anthers? No. These are not present. This floret you see differs from those in the centre in three important ways,—in shape, in colour, and in having no pollen-producing parts. It is a **female flower.**

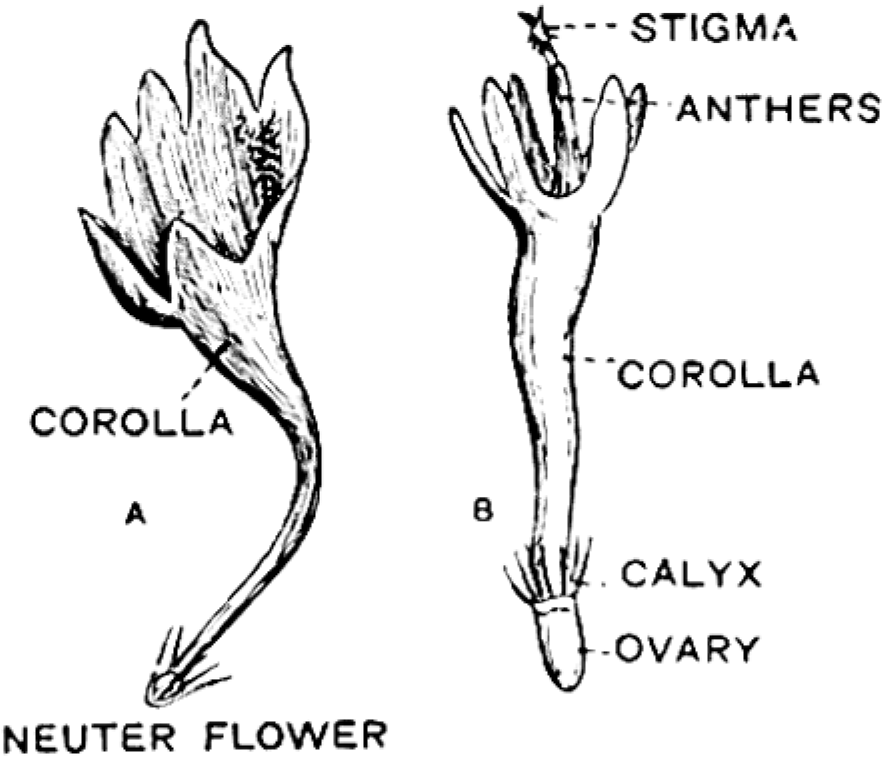

Fig. 57.—Tubular Florets of Cornflower (*Centaurea*).
The outer ones (A) are neuter, *i.e.* they are for attraction only and have no pollen or ovule bearing parts. The central florets (B) of the capitula are complete.

Now here is an interesting point—a little thing full of meaning, as little things very often are. Look once more at the style of the white floret. Does it have sweeping hairs? No. The style of the yellow floret does have hairs. Of course you see the meaning of the difference. What is it? There is **no pollen in the white flower,** therefore it cannot be self-pollinated. Hairs would be quite useless here.

Daisy and Dandelion compared.—Look once more at the entire daisy. We have seen some interesting differences between it and the dandelion. They both agree in having the flowers massed in heads, an arrangement which causes them to be readily noticed.

But in what way may the daisy be said to be more conspicuous than the dandelion? In having **two contrasting colours** on its head, in having **two differently shaped kinds of florets**, and in having these arranged in two groups, the central or **disc florets**, and the outer or **ray florets**, so that the whole forms a star-like shape, such as very readily arrests the eye. There is no doubt all these things make daisies very easily found by insects of various kinds. For these come abundantly, finding both nectar and pollen.

It is likely, too, that in the daisy there is **saving of material**, for the disc florets are smaller, without any loss in conspicuousness.

Questions.—From a daisy head carefully remove a few bracts in series, note the manner in which they are placed and the number of rows. What purpose do they serve?

How does the daisy compare with the dandelion as regards its habits? They are very similar. How does it behave in dull weather and at night?

What is noticeable in the arrangement of its leaves and in their shape? What are the advantages of these things? In what other way do daisies multiply besides by producing seed? These are all questions which you should not find it difficult to answer, especially if you dig up a complete plant and its connections.

Are daisies common? Yes, very common. But we do not despise them on that account, for a study of the structure and habits of growth shows that **commonness amongst plants means success** in existing in large numbers where others manage to maintain a footing only with difficulty.

Exercises in Classification.—Plants whose flowers have the arrangement and structure we have seen in the dandelion and daisy are known as **Composites.** They are very numerous, just because their arrangements, as we have seen, are good ones for enabling the plants to succeed. You must try to get to know a good many of them. They are very easily recognised. As an exercise in classification collect as many different kinds as you can, and **group them after examination** under the proper heads as shown below.

1. *Liguliflorae.* That is, florets with strap-shaped corollas only. These florets have both stamens and pistil, and the plants have a milky juice (**latex**). Examples are **dandelion, smooth hawk's beard, cat's ear, goat's beard.**
2. *Tubuliflorae.* Without milky juice.
    - (*a*) With all the florets tubular—**thistles, knapweed, cornflower,** etc. (Fig. 57).
    - (*b*) With disc florets tubular, and ray florets strap-shaped—**daisy, ragwort, yarrow,** etc.

Learn to recognise at least a dozen plants of the Order Compositae.

LESSON XXV.

THE TREES IN SUMMER.

[The teacher should accompany the pupils in a visit to suitable trees in the neighbourhood, and suitable material for the indoor exercises suggested below should be collected at the same time. Evergreens are not under consideration in the present study.

The points dealt with in the following provide material for a series of lessons. All of these need not be given in one season. The general scheme of the whole work may be indicated thus:—

I. Recognition of common trees. This constitutes Exercises in Observation, and must be performed out of doors. The pupils are to tabulate in their note-books information ascertained at first hand regarding a set of trees as under:—

Name and situation.
Height.
Shape.
Density of foliage.
Bark, appearance of.
Leaves—simple or compound; size; if mosaics are conspicuously observable, and their features.

II. Indoors the teacher should give notes upon the work of trees in summer.

III. Exercises in the recognition of different tree leaves. A preparation for this will be got under I. above, but the teacher can greatly extend the scope of this lesson by the introduction of leaves not observed there. A series of leaves should be carefully drawn and named. Also the several parts of leaves should be named and recognised in this lesson.

IV. A lesson on the work of leaves.]

General Instructions to Pupils.—In the spring time you had an opportunity of becoming familiar with the appearance of the trees when in flower and at the time of opening of their buds. If you have been watching these as the year progresses you will ere now also know them in their summer foliage. Just as the bud and flower are the noticeable features about the trees in spring, so in summer abundance of foliage is the season's badge.

Trees are easiest of recognition in summer, and you should pay a visit to the parks if you live in town, or in the country to wood, garden, or elsewhere wherever trees are growing in the school neighbourhood and make sure that you know them all at sight. If you wish to know each tree at its best you must see examples which are growing in fairly open spaces. When trees are growing too closely crowded together, or too much sheltered on one side, they do not grow quite symmetrically and the perfect form which a strong healthy tree ought to have is lost.

General Appearance of a Tree in Summer.—In examining a tree you ought to have your note-book with you and write down the **name of the tree,** whether tall or otherwise. Your teacher will be able to guide you if you wish to put down its probable **height.** Then try to get a general idea of its **shape,** and write this down also. An ash tree, for example, may, if growing in a good situation, be rounded or ovoid (egg) shaped. A typical horse-chestnut has a fine broad pyramidal form. Poplars are generally rounded and close, Lombardy poplars tall and conical.

Next you should note the **density of the foliage.** Write down whether the tree has thick foliage, *e.g.* sycamore, beech, or horse-chestnut, whether the foliage is more or less open and permits the passage of a good deal of light, *e.g.* ash or birch. Try to arrange the trees you know in the order of density of foliage. If you know of woods of one particular tree, note the amount and nature of the undergrowth.

Note carefully those cases where you can see clearly a **mosaic** arrangement of the leaves upon the branches. If convenient your teacher will obtain for you a few branches illustrating this feature of tree life. You must when indoors carefully draw the specimens. Elm, lime, sycamore, horse-chestnut are common trees showing very good mosaics (Fig. 58). What is the meaning of leaf mosaics? Why are they necessary? Be quite sure you can answer these questions correctly. In a "mosaic" the leaves are arranged so that they do not intercept the light from each other.

Bark.—Examine the bark of the tree and write down its appearance, whether light or dark coloured, smooth or rough, peeling, scaly, or fissured, and so on. Can you describe the bark of the beech, silver birch, rowan, ash?

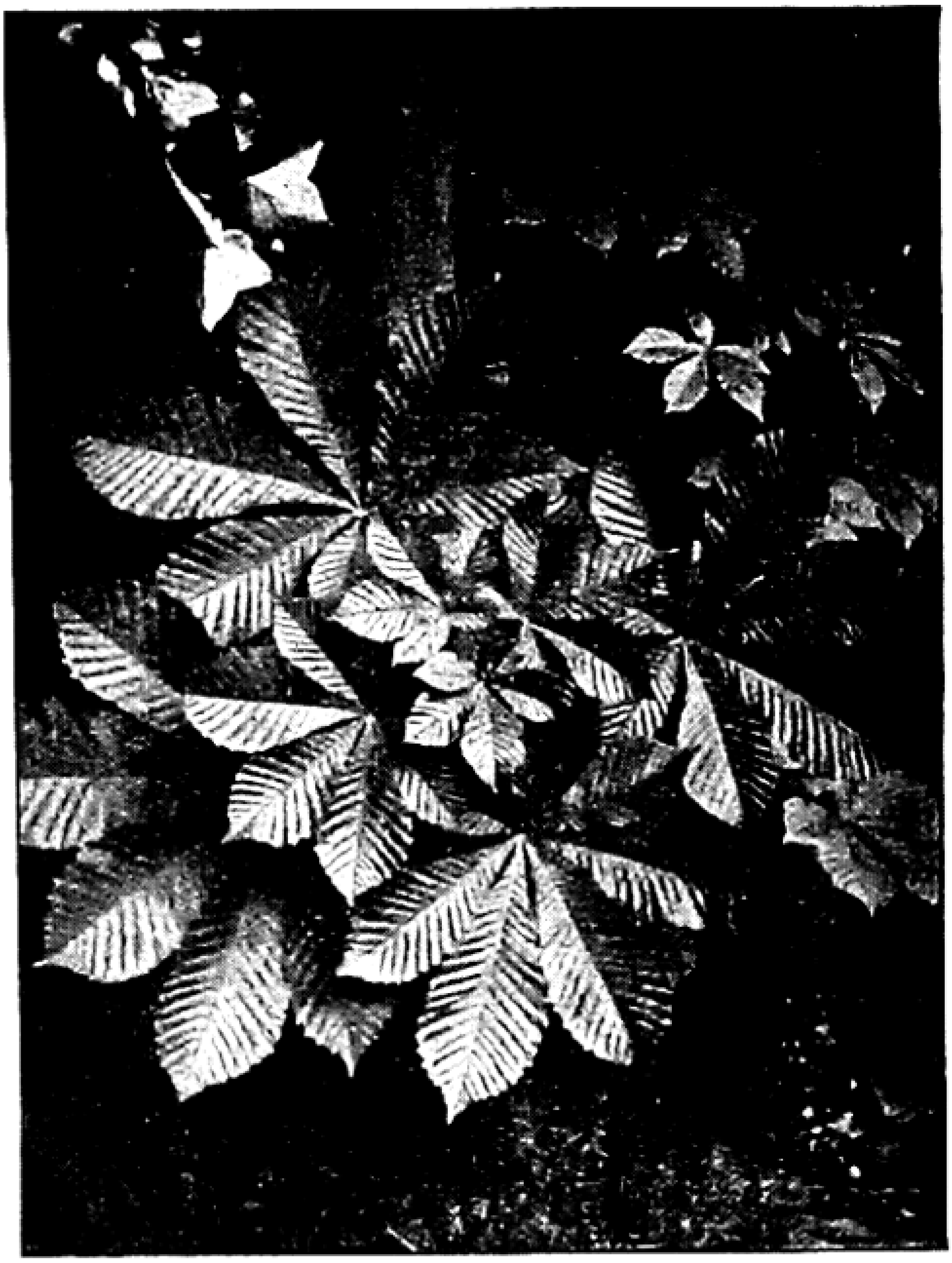

Fig. 58.—Leaf Mosaic illustrated in Horse-chestnut foliage.

Simple and Compound Leaves.—Bring to school good specimens of leaves of all the trees you have seen and named. Group them as follows:—

Simple leaves—those in which the blade is in one continuous piece. Examples are beech, lime, oak, apple, birch, hawthorn, sycamore, poplar, hazel, holly. Compound leaves—those in which the blade is divided up into a number of separate parts termed leaflets. Examples are ash, rowan, horse-chestnut, laburnum (Fig. 59). The shapes of leaves have probably been dealt with in earlier lessons in school. But they may be revised at this stage.

Leaf of Ash.—You may not be quite clear as to how to distinguish a compound leaf from a branch with leaves. Let us take the leaf of the ash as an illustration. This leaf I have here has five pairs of leaflets each quite large. The central stalk, which is really the midrib of the leaf, is eleven inches long, and the leaflets are from 3¼ to 5 inches long. Why is it not correct to call the central supporting stalk portion a branch and the leaflets simple leaves? (Fig. 60).

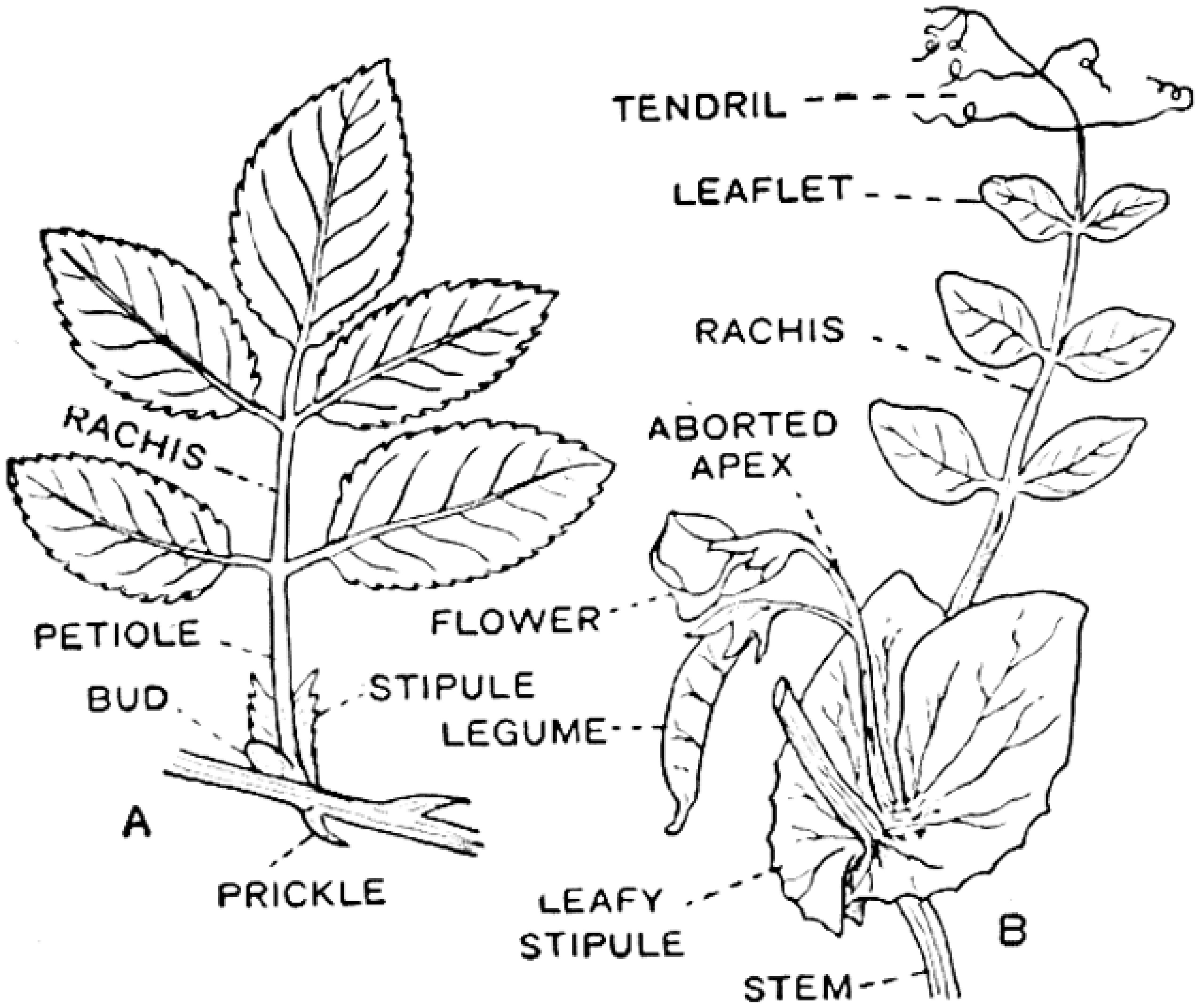

Fig. 59.—A, Compound Leaf of Rose, with five Leaflets and Stipules; B, Compound Leaf of Pea, with terminal Leaflets modified into Tendrils.

Characters of a Leaf.—First of all the supporting part is not a branch because it does not bear a bud at the tip or a growing point there. These are marks of a true branch. Then when we look at the place upon the tree from which this part was taken we find a bud immediately above the place whence it arose. This is a feature of a leaf. Leaves have buds just above their origins. This place where the bud arises is termed the axil of the leaf. Then if you look at the leaflets you will find that they have no buds in their axils. Therefore they are not really leaves but parts of a leaf only (Fig. 61).

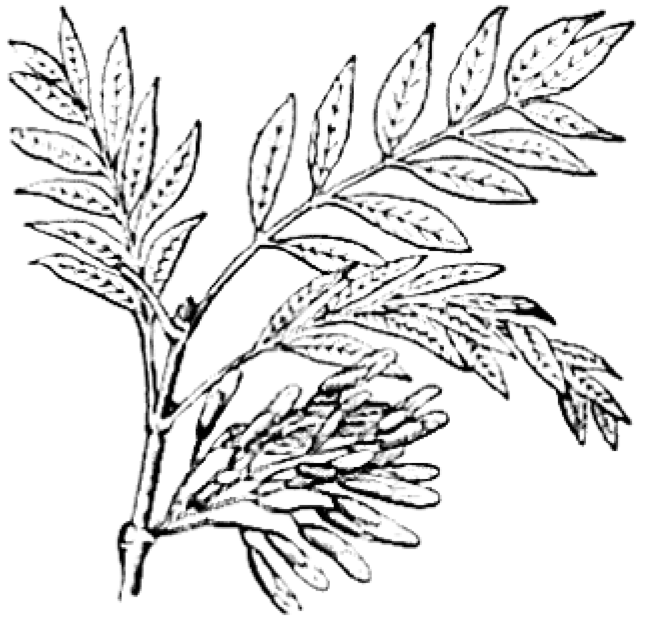
Fig. 60.—Twig of Ash with a cluster of fruits and three leaves.

Parts of a Leaf.—You must now make a set of drawings of tree leaves, simple and compound. As you do that you will discover a number of interesting things about particular leaves. But first of all let us be sure that we know the names of the various parts of a leaf. Draw first a simple leaf, such as the leaf of the beech. Name the following parts: blade or lamina, midrib, veins, leaf stalk or petiole, leaf base. As a result of your examination and drawings answer the following questions:—

What is *distinctive* in the shape of an elm, a sycamore, and of a lime leaf? What purpose does the peculiarity serve? It is part of the mosaic arrangement which these leaves exhibit.

What is the difference in the texture of a lime leaf and a black poplar?

How many leaflets are there on a laburnum leaf?

What is the shape of a rowan tree leaflet? Is the terminal leaflet the same shape as the others?

Which common tree has the largest leaves?

Which has the smallest?

Identify twelve common trees by their leaves.

The Work of Trees.—What are the trees doing in summer? With their roots they are absorbing mineral

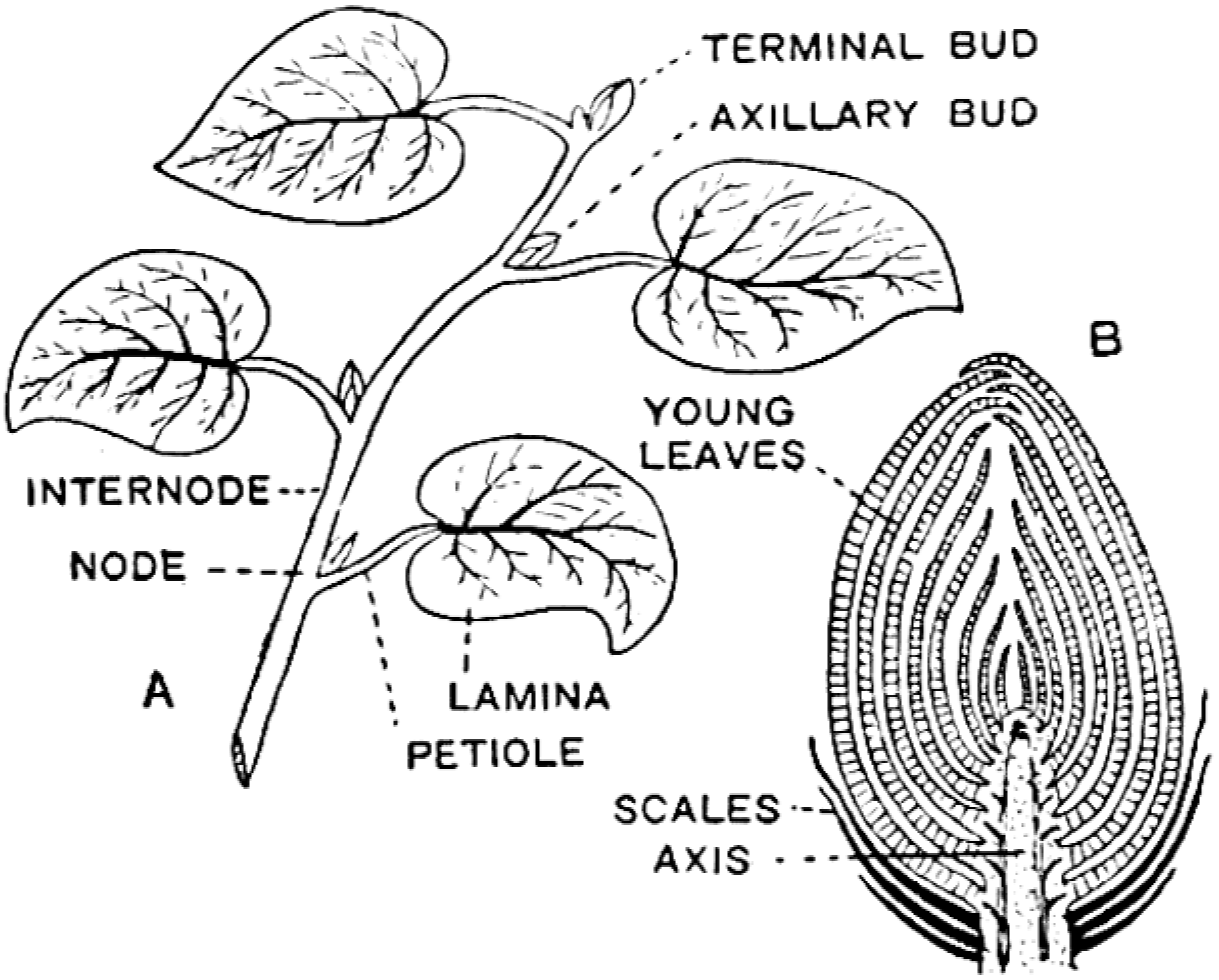

Fig. 61.—A, Twig with leaves and buds; B, Section of bud enlarged.

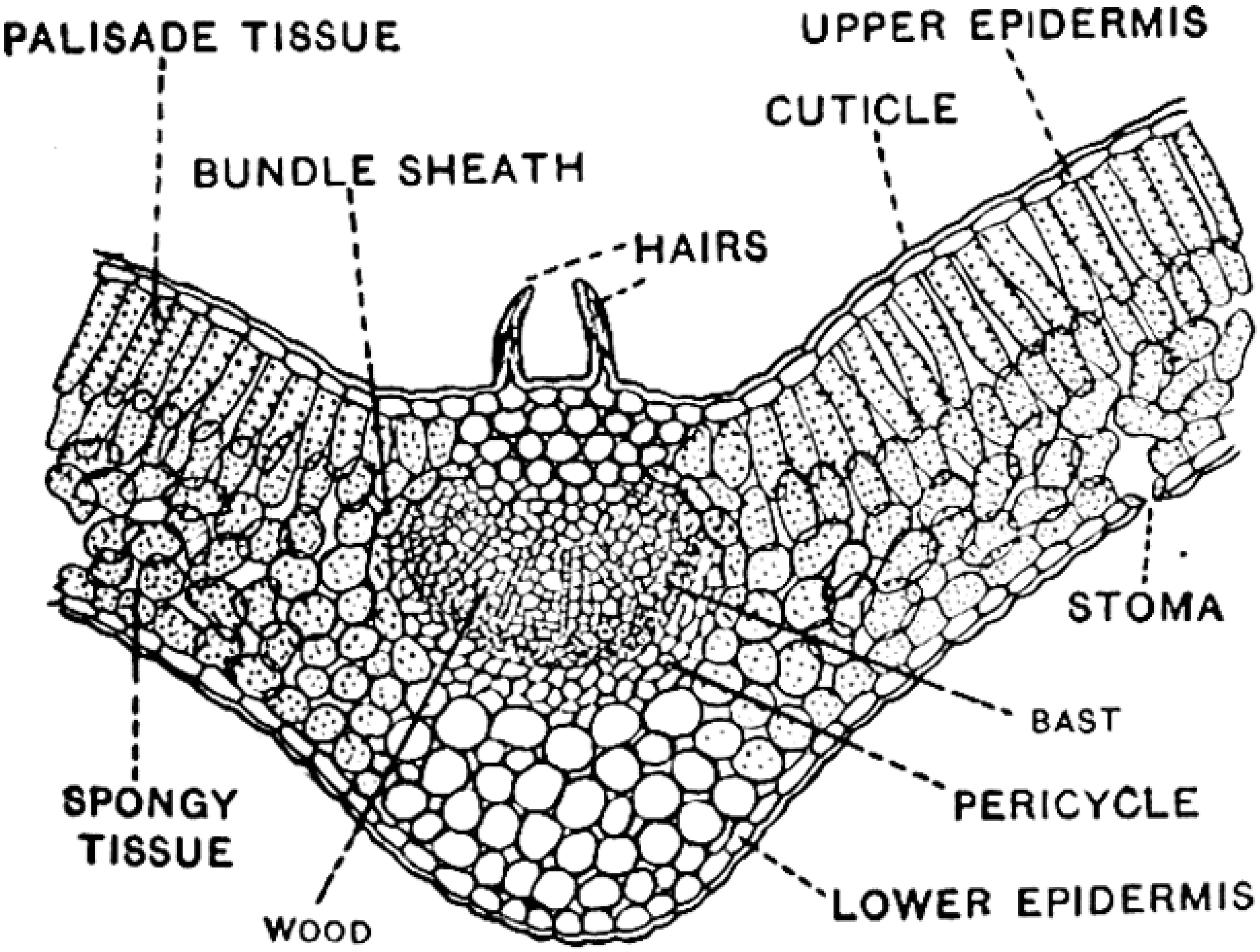

Fig. 62.—Section through a leaf of Privet. The wood and bast form the chief constituents of the vascular bundle or conducting tissue.

substances dissolved in water from the soil and passing it up the later-formed wood of the trunk and branches. The leaves are making carbon containing foodstuffs, which are distributed down the branches and trunk to the various regions of the tree so that it grows as a whole.

Work of Leaves.—The leaves of those trees we are considering cease working in autumn and fall from the trees. Fresh ones take their place in spring, but the working period is, you see, only a part of the year. They have to make the best of it, hence the great competition for light, because, as you have already learned, leaves cannot make food without sunlight.

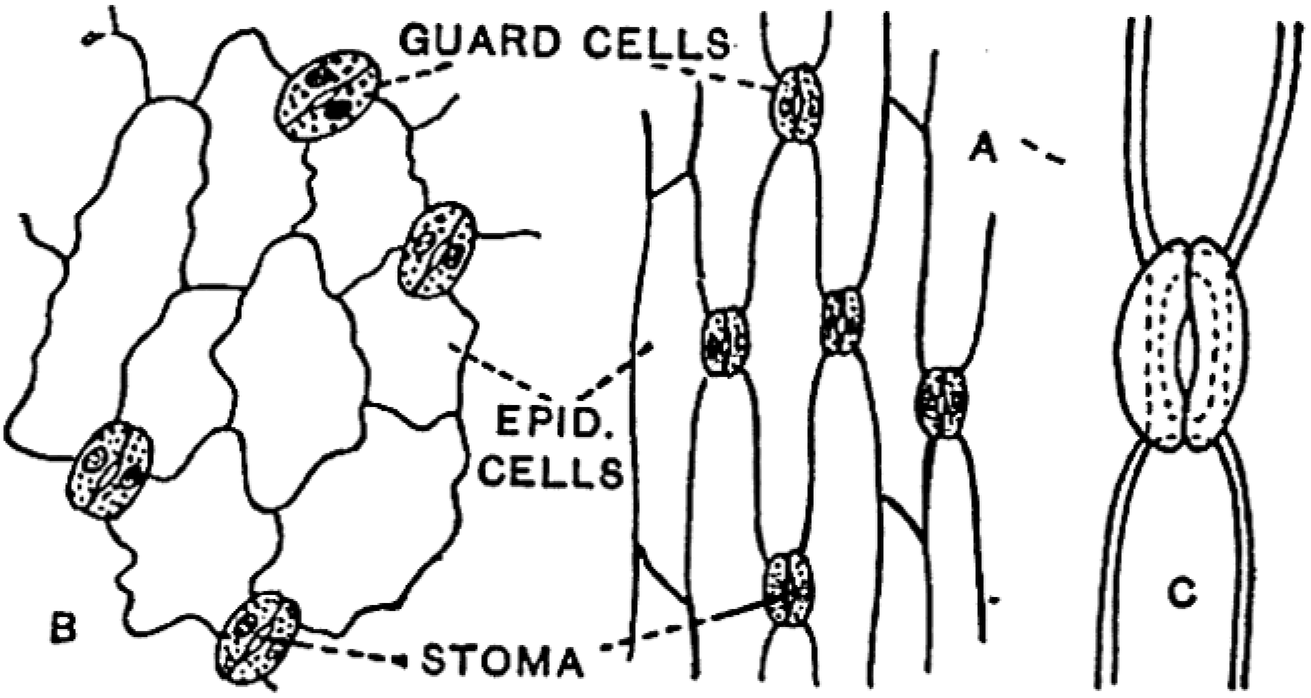

Fig. 63.—Examples of Stomata with their guard cells, from the epidermis of the leaves.

Let us revise the uses of the various parts of a leaf. Take any common tree leaf and note the following: the leaf is lighter below than above. This is because there are air spaces within the leaf. These are most numerous towards the under side. The tissue within the leaf is usually more compactly arranged just below the upper surface (palisade layer), and loosely towards the under side (spongy layer). (The teacher might illustrate the general structure of a leaf and the uses of its parts by means of a diagram, Fig. 62.) The openings (stomata) leading into these are mostly on the under side (Fig. 63). The upper side of a leaf frequently is thick and glossy. This is due to a thickening of the upper "skin" (epiderm) forming a cuticle. What is the meaning of these facts?

An important part of the work of a leaf is the passage into the air of moisture brought up by the roots. This requires regulation, and in particular its passing off too fast must be avoided. That is why the openings are most numerous on the under side, sheltered from the direct rays of the sun, and why on the upper side there is a special protecting cuticle.

What do the green parts do? The leaf-green (chlorophyll) has the power in sunlight of splitting the compound carbon dioxide—separating the carbon from the oxygen. The oxygen is set free into the air, the carbon is united to hydrogen and oxygen to form starch and other substances.

What do the veins in the leaves do? The veins are conducting passages for the food—the dissolved mineral matters upward (through the wood) and the formed food materials for the tree downward (along the bast).

There is another important function which goes on within all plants, viz. breathing, which must not be forgotten here. Through the openings, especially in the leaves, plants take in oxygen, which they build into their living matter just as animals do in breathing. Besides the stomata in the leaves there are openings (lenticels) in the stem and twigs which serve the same purpose. Examine some twigs for these (see p. 371).

In your studies of trees in summer while you examine leaves and bark minutely do not overlook the importance of studying the tree as a whole. Try to appreciate the beauty of trees and to be able to describe their general appearance expressively. Read the descriptions of various trees by well-known writers.*

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* *Nature Study*, pp. 251-2.

To what does the expression "hoar-leaves" refer in the following?—

> "There is a willow grows aslant a brook,
> That shows his hoar-leaves in the glassy stream."
> —*Hamlet*, IV. vii 167.

Of what tree has the following been written?—

> "Thy foliage, like the tresses of a Dryad,
> Dripping about thy slim, white stem, whose shadow
> Slopes quivering down the water's dusky quiet,
> Thou shrink'st as on her bath's edge would some startled Dryad."
> —LOWELL: *The Birch Tree.*

LESSON XXVI.

THE GERMANDER SPEEDWELL (*Veronica Chamaedrys*).

[A specimen for each pupil should, if possible, be provided. This plant flowers from April to September, but is most abundant in May and June. It is common by shady waysides.]

This is a pleasing little flower of the wood banks and waysides. As you look at it in all its freshness amongst the crowding herbage, what do you think are its specially attractive features? Is it not the brilliant blue colour and contrasting white centre coupled with its small size? Apart from its attractive appearance this little flower shows some interesting features in connection with the insects which seek its nectar. In the present study we shall try to understand these.

The Parts of the Flower.—First make a simple drawing of the flower, viewing it from above. As you do this, notice the following things. There are four bright blue petals. Behind, there are four narrow green sepals, but these will not appear in your drawing. Are all the petals of the same size? No, the upper petal is broadest, the lower is narrowest, the two side petals are equal and intermediate in size between the upper and lower. The colour is bright blue—"the little speedwell's darling blue"—streaked with darker lines pointing towards a white centre.

How many stamens are there? Two. Do you observe how these are placed? They arise opposite the side petals and bend outward away from each other. Touch them gently with a needle or pin. Do you see how readily they can be bent inward towards the centre, and how they return to the former position when released? This is a rather important feature in this flower, as we shall see.

How is the pistil placed? It stands out from the centre of the flower as far out as the stamens do, but inclined downward in front of the lower petal.

From the position of the stamens and pistil, you will see that, even although it is the case that all are ripe at the same time, it is very unlikely that the pollen ever without interference reaches the stigma of the same flower. The arrangement of parts in fact is such that **self-pollination is prevented.** Look carefully once more at the flower and think over what you see until you are quite sure you understand this.

Pollination.—How is pollination carried out? Down the corolla tube the ovary is situated and below it the nectary. You may find the tube moist with the nectar which has collected within it. This flower is visited largely by flies, known from their manner of flight as **hover-flies** (see p. 288), particularly by a small one known as *Ascia*. Various **burrowing bees** are also visitors to this flower.

If you could spend some time in the sunshine near where the speedwell is growing you might see how easily and surely the hover-flies cross-pollinate this flower. The fly approaches the flower, hovering close in front after its usual mode of flying. Then supporting itself by holding on with its fore limbs to the two stamens it settles upon the lower petal and, inserting its proboscis in the corolla tube, draws off the nectar.

Notice what has happened to the flower while this routine has been gone through. As the fly alights the pistil, which is projecting outward and downward, touches the under side of its body. As the fly lays hold of the stamens, these are drawn inward under the body also and rub against it, causing the pollen to adhere. When next the insect visits a flower it transfers some of this pollen to the pistil as it alights. This takes place before the pollen of the same flower is deposited upon the fly. In this way you see cross-pollination is effected.

Notice especially the following.

1. The flower, owing to the shape of the upper and lower petals, is a bilateral flower. Bilateral flowers usually have more *definite* relations with insects than radial flowers. In the speedwell this is slight, and yet we have seen the close relations existing between the arrangement of parts and the visits of insects.

2. This flower has an "eye" and "honey guides." What is the value of these to the flower? We have asked this question several times already in other cases. It is interesting to note how this feature has helped to give more than one popular name to the flower. It is sometimes termed "bird's eye." It is also known as "cat's eye," and in Devonshire a still prettier name is found.

> "Around her hat a wreath was twined
> Of blossoms blue as southern skies;
> I asked their name and she replied,
> We call them angel's eyes." *

Notice the grouping of the flowers on a single plant. They are upon short stalks at the base of each of which there is a narrow pointed leaf (bract). How are the flowers arranged? In a spiral upon the flowering stem. Plants growing in open places amongst scanty vegetation have the flowers facing all round, but on a crowded bank they all turn outward so that they have a better chance of being found by insects.

After Pollination.—Look for plants whose flowers have been pollinated. Notice how the flowering axis has lengthened, how the flower stalks have become erect. Can you think of the value of this? It ensures the throwing of the seeds some distance away when the wind shakes the plant. Note that the sepals are still present upon the fruit—shake a fruit and you will see that the sepals prevent all the seeds coming out at one time.

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* Quoted from *The Folk Lore of Plants* by T. F. Thistleton Dyer.

Leaves.—Examine and draw the leaves. Why are they described as **cordate**? What name is given to a margin such as these leaves have? How are the leaves arranged upon the stem? Opposite, each pair crossing the next at right angles. What is peculiar in the arrangement of the hairs upon the stem? There are two opposite rows of hairs, which change their position at each pair of leaves.

A lesson upon similar lines to the foregoing may be given at another time upon the figwort (*Scrophularia nodosa*). This species, which has small brownish green flowers, is pollinated by wasps. It affords an illustration of protogyny (stigma ripe before stamens). In the young flowers the stigma may be seen protruding from the flower, whilst the unripe stamens are curled up below with the anthers directed inward. By the time these have ripened and have been turned outward in the mouth of the corolla the style has withered.

LESSON XXVII.

THE WHITE DEAD-NETTLE (*Lamium album*).

[The white dead-nettle—a common weed—is the species more particularly considered in the following lesson, although in general the facts brought out apply to other members of the genus. *L. album* has the advantage of being larger than most of the others. The pupils should be given entire plants to examine.]

General Features.—This is a fairly common wayside weed, which we shall study because of the many illustrations it affords us of the fittedness of living things to their place in nature and to the work they have to do.

The so-called dead-nettles are not nettles at all, but belong to an Order of flowering plants called the Labiates, because of the lip-like fold in front of and below the opening into the flower. Examine the flower before you and point out this lower lip. Some other interesting features of this Order which you can easily observe are the overhanging hood-like part which is present in their flowers, the shape of the stem, which you notice is not rounded but rectangular—square in section—hairy and hollow, and the arrangement of the leaves in pairs crossing each other at right angles. Notice, too, the rather peculiar clustering way in which the flowers are grouped around the stem (verticillaster) (Fig. 64).

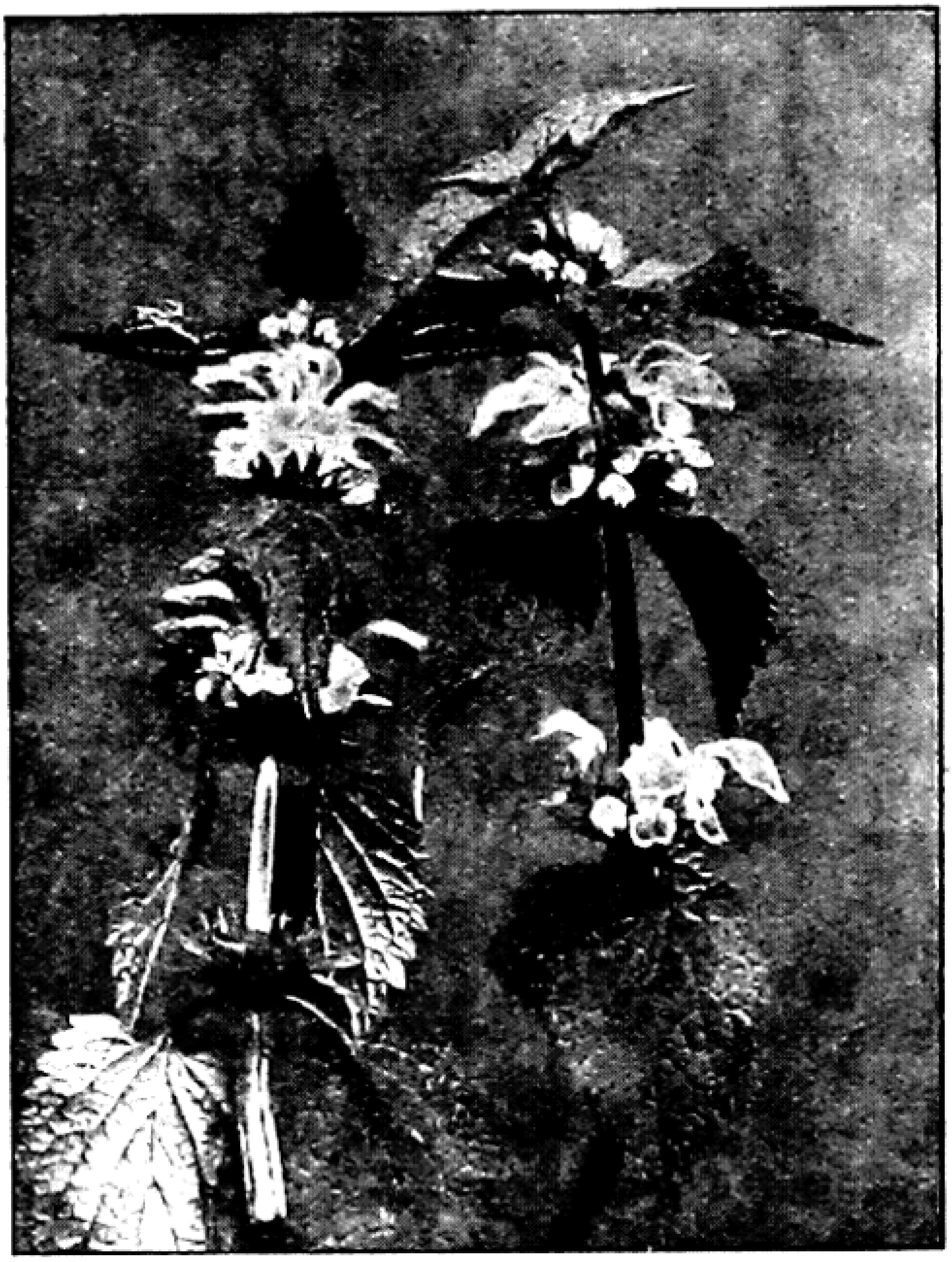

Fig. 64.—The White Dead-nettle.

If you remember these things you should not find it difficult to recognise a labiate plant. Here are the names of some common ones which, if you can find, you should examine and notice how they agree in all the particulars we have named: self-heal, woundwort, blue bugle, wood-sage, sage, ground ivy, mint.

Leaf Arrangement.—Now, looking at the dead-nettle in front of us, let us take first one illustration of fitness from the leaves. You have already noted their arrangement—a succession of pairs at right angles to each other. Can you say what is the particular advantage of this arrangement? When we examine a great many different kinds of plants we find a good deal of variety in the ways in which their leaves are grouped, but we can usually see one general advantage in them all. What is that? It is that the leaves upon each plant are arranged so as to keep out of each other's way as much as possible, and thus permit of all getting a certain amount of light.

The grouping in the dead-nettles is one of the best that exist for this purpose. Notice that this arrangement gives a long gap between any single leaf and the one directly above it. Notice further that the upper leaves (partly because younger) are smaller than those below and never grow to be so large, that the lower ones have longer leaf stalks, and thus extend further out. If you look directly down upon the plant you see that all the leaves are visible. You have already learned that when leaves "fit in" to each other in this way the grouping is known as a **leaf-mosaic.** You should try to draw this mosaic—filling in simply the outlines of the leaves.

Examination of the Flower.—Now let us look at the flower. Observe first its colour—white, with yellowish under lip dotted with dark green. The shape is specially interesting. First we note its **bilateral symmetry** (having a right and left side). That means that it has special attractions for insects. Before we look what these are it will be interesting just for a moment to trace the composition of this corolla.

Notice first the calyx. How many parts are there? We easily trace five, although they are united for a little way into a short tube. Can we trace five parts in the corolla? So far we can. The lower lip you observe is situated between two sepals; above the lower lip, guarding the entrance to the flower, on the sides are a pair of lobes which represent a pair of petals, then over the top is a large projecting hood, representing the two remaining petals more completely united than any of the others. Notice that a single sepal stands behind this hood-like portion. It really marks the position of the line along which the two petals are now joined (Fig. 65).

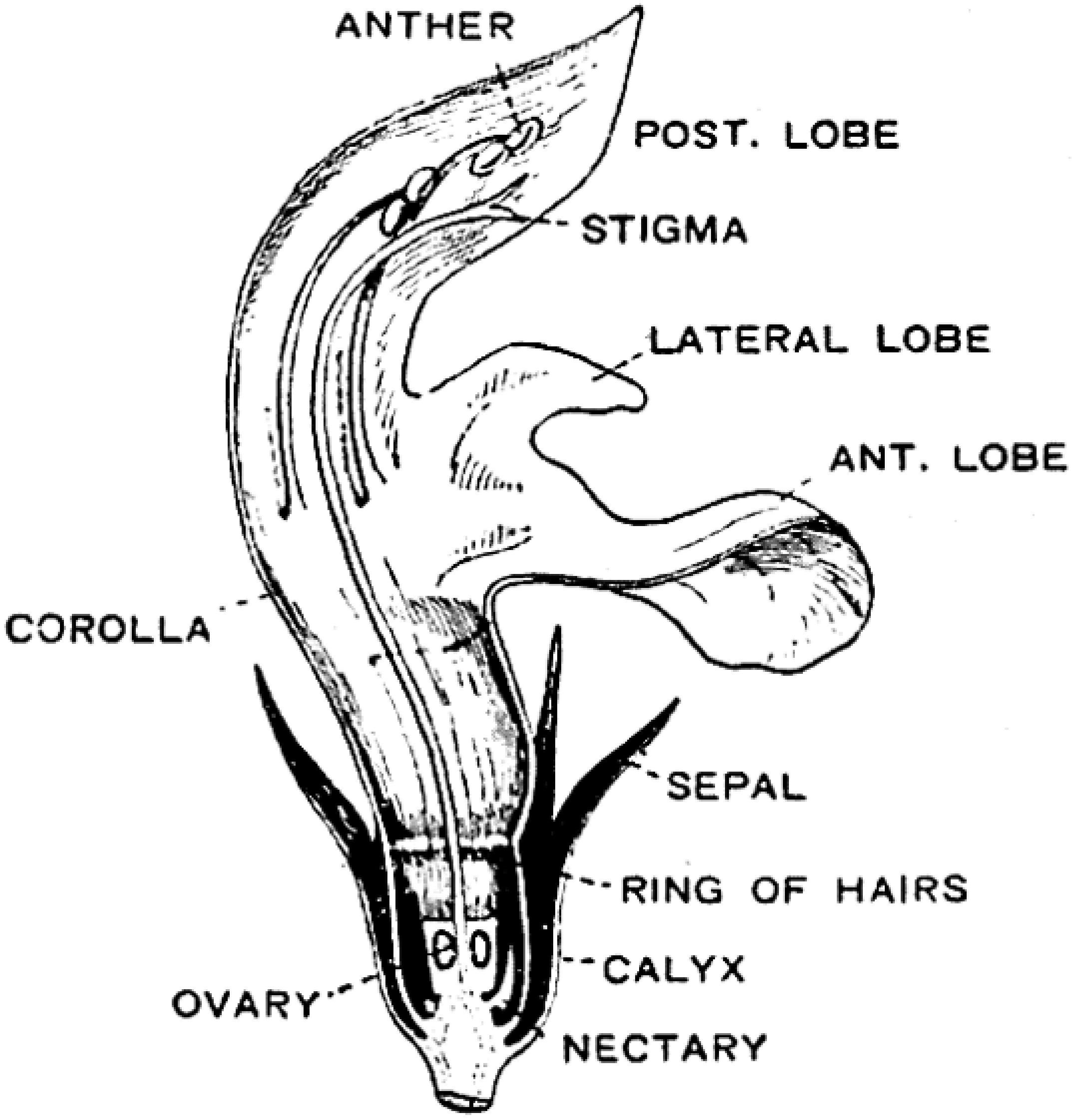

Fig. 65.—Half-Flower of White Dead-nettle.

Once more look at the flower carefully, this time thinking of it as a thing of five parts altered or modified for a special purpose. If you do this you will be the more prepared to ask what advantages have resulted to the flower in having its parts formed in this way. Well, we shall try to see.

First of all we should know that this flower yields good supplies of nectar. This nectar or honey is formed inside the flower at the base of the ovary. It is intended only for insects which in visiting the flower can effect cross-pollination at the same time. The nectar is placed at the end of an open tube. But as this open tube admits small insects which can creep about inside the flower without touching stamens or pistil, these are prevented from reaching the nectar by a **thick circlet of hairs** in the throat of the tube. Open a flower so as to see those hairs (Fig. 65).

The size of the flower is suited best to **humble bees.** They are attracted to the flower by its colour, and find a suitable resting-place on the lower lip just in front. The two side lobes are suitably placed so that the insect's head can be inserted between them. In reaching down the tube to the nectar the bee's back or even the hinder part of its body is tilted up and presses inside the overhanging hood. Try to realise this as you look at the flower, or better still, watch the bees on the flowers out of doors.

Now the four stamens and stigma are situated here. Observe that the stigma has a cleft surface, and its lower limb is turned downward so that it is below the level of the stamens. The result is that when a bee is boring down into the flower, as its body is pressed up under the hood, the first part to touch it will be this lower limb of the stigma. But every bee rifling dead-nettles after its first visit will carry pollen on its back, and so cross-pollination will result.

The hood, besides serving to ensure that the bee's back will be rubbed against the stamens, also serves to keep these dry in time of rain. If insect visits should fail—which rarely happens with this flower—the stigma being situated close to the stamens is quite likely to receive pollen from them, so that seed is always sure.

The length of the tube between the platform and the nectar prevents small insects (not big enough to touch the stigma and anthers when probing) from getting at the honey because their tongues are too short. Sometimes these insects **bore a hole** at the side and suck the honey in this way. If you should find flowers cut in this way, you will know that honey thieves have been at work.

Make a drawing of a flower in section and try to realise with its help the whole process of pollinating.

LESSON XXVIII.

THE FOXGLOVE (*Digitalis purpurea*).

[The foxglove flowers from early June to August, in light soils in dells, woodbanks, and other more or less open places. Garden varieties might be used for lesson purposes if difficulty is experienced in finding wild examples.]

General Appearance of the Plant.—This is one of the largest and amongst the most attractive looking of our wild flowers. Notice first how conspicuous the plant is amongst the other wild plants growing near. It is taller than the tallest of the grasses around it, the long erect flowering stem swaying in the wind above their heads. The flowers themselves are large, and they are ranged close together for some distance along one side of the upper part of the stem. They are brightly coloured also. Altogether the position, form, and size of the inflorescence combine to make the plant conspicuous. At the base there is a cluster (rosette) of large and somewhat downy green leaves which carry on the work of making food, and which by their size and arrangement manage to keep a clear space around the base of the plant so that they get a sufficient amount of light. You must take the first opportunity of seeing foxgloves growing wild.

The Flower in Relation to Insect Visits.—Make a drawing of a foxglove plant and answer the question: What is the advantage of conspicuousness in this case? In the sunlight in summer you may see the insects visiting the flowers. What are the commonest insect visitors? They are **humble bees** (e.g. *Bombus hortorum*). Notice two things of real significance in connection with the visits of bees. First the **form** and **size** of the flowers. The obliquely bell-shaped corolla just fits the body of the bee, making it easy for it to maintain its foothold within. Then the **arrangement of the flowers** all towards one side make a succession of visits by the same bee easier, and less time is taken in going over the plant. A third thing worth noting is the droop of the individual flowers which protects the pollen from the rain.

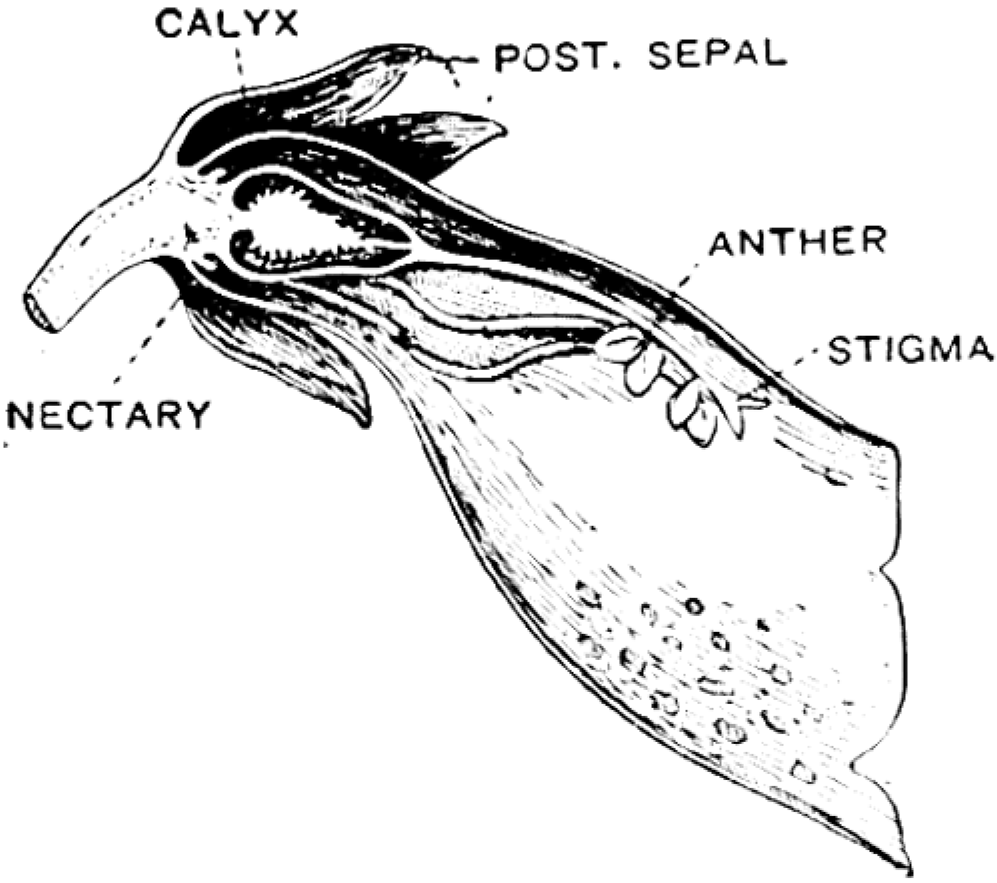

Fig. 66.—Half-Flower of Foxglove.

Take now a single flower and examine it in detail. There are five small sepals. Notice that they are not all equal in size. State exactly how they differ. Note next the corolla. It is tubular, bulging towards the lower side, constricted towards the base, with a whitish dilated part beyond the narrow neck. Can you think of the meaning of this narrowing of the tube?

Is the edge of the bell even or lobed? There are five lobes. What does this mean? The corolla consists of five petals united into a long tube but showing traces of these five parts at the free end.

What is the **colour** of this flower? A reddish purple, and in shape it suggests the finger of a glove (digit). For these two reasons it has been named in Latin *Digitalis purpurea*. Can you think why we call it the foxglove? It is not easy to answer this question. Some say, the "folk's-glove," the fairy folks of the dells and woodlands where it grows. But it has other names, *e.g.* dragon's mouth.

In the throat of the flower you can see the cluster of spots towards which the visiting bees are attracted and on which they alight. Here, too, are numerous hairs which assist them to gain a foothold.

Where are the stamens and pistil? These are lying close against what is the upper side of the corolla in its natural position upon the plant. Note the two pairs of stamens at different levels (Fig. 66). You must examine a number of flowers of different ages. Touch the stamens in each flower carefully with a soft brush, and in this way learn from the pollen carried away to distinguish those flowers with ripe stamens and those whose stamens are not yet ruptured. You may with practice be able to tell the difference by the eye alone.

When you are able to tell by the condition of the stamens the younger flowers from the older compare the condition of the stigma in each. What do we find? In the younger flowers—that is those with unripe stamens, the stigma is pointed. In others whose long stamens are shedding pollen, the stigma shows signs of opening out into two lobes, whilst in those still more mature with pollen shedding from the shorter stamens the stigma lobes are spread out, and this organ is mature. Clearly the anthers are ripe before the stigma (Protandry). Make sketches of the different conditions in which you find the stigma.

If you think of the meaning of these discoveries you will see that the arrangements here **favour cross- rather than self-pollination,** and that bees in passing from the younger to the older flowers will carry pollen from the stamens of the one to the stigma of the other. The nectar which they seek is formed by a ring-like swelling at the base of the flower and gathers at the bottom of the tube behind the narrow neck-like part. As the bees probe for this they rub their backs upon the stamens and stigma.

Sometimes when many bees visit a flower all the pollen is removed before the stigma is ripe, and then cross-pollination is sure to take place as the visits continue. Sometimes the visits of bees are few, owing to rainy or dull weather or other causes. In such cases, as the lobes of the stigma spread out they may come in contact with the pollen of the same flower, and in this way self-pollination may result.

In order to understand all this clearly, it may be necessary for you to open the flower so that you may see how the various parts are connected with each other. When you do this you should make careful drawings of what you see. Do not hurry over it; repeat your examination of the parts of the flower until the meaning of the arrangements is clear to you.

The Ovary and Fruit.—Find upon a flowering stem some fruits. They appear first in the lower part of the flower group (inflorescence). Cut through an unripe one and note the two chambers in which the seeds are forming. Examine a well-ripened fruit which is ready to split open, and notice that it splits along the partition separating the two chambers.

Duration of the Plant.—Can you recognise a foxglove plant without the long flowering stem? Have you noticed that in summer there are plants both with and without flowers? Can you give a reason for this? The foxglove is usually a biennial plant. That is, it does not flower until the second year, after which it dies away. But in other cases the plant persists for a number of years. In such a case it is a perennial.

The Order Scrophulariaceae, to which the foxglove, speedwell, and figwort belong, is one which the teacher should take some pains to become familiar with. It will provide material for lessons of considerable interest because of the mechanisms for effective pollination through insect agency. A careful examination of the details of the flowers, accompanied by direct observations made upon the plants during insect visits, will constitute the best preparation for school lessons. Suitable examples are *Antirrhinum* (snapdragon), *Linaria* (toadflax), *Pedicularis* (lousewort). An account of the general characters of the Order will be found in any good botanical text-book, *e.g.* Lowson: *Text-Book of Botany* (Univ. Tutorial Press).

LESSON XXIX.

A SUMMER EXCURSION IN SEARCH OF WILD FLOWERS.

[The teacher, upon an excursion of this nature, should carry a note-book, vasculum, and digger; the pupils should have note-books in which to record the plants found, and to make notes upon facts of interest in the situation, habit, or other feature of the plants noted. The teacher's collection is to be used for revision in school. The suggestion given in the present instance should be used in lessons on the plants dealt with. The various points mentioned will afford an illustration of features to which pupils' attention might suitably be directed. The teacher who has not had much experience in dealing with plants will find it profitable to obtain as many as possible of the plants mentioned below and to verify upon them the various points quoted in the lesson.]

It is a pleasant afternoon in midsummer on which we wend our way along a pretty roadway on the outskirts of the town. This roadway is narrow and is planted with trees at short intervals on both sides. Already their fruits are scattering, and we note under our feet those of sycamore, ash, and willow in abundance, with stray specimens of the prickly capsules of the horse-chestnut. The roadway is well shaded at this part, and on one side there is a sloping grassy bank towards which, for a little, we direct our attention.

At the margin, where the herbage is shortest, we note an abundant growth of the **creeping buttercup** (*Ranunculus repens*). Here it has obtained a good hold, its branches are fairly erect, its foliage abundant and overshadowing so well that few other plants are able to exist near it. Its creeping stems rooting at the nodes, and abundant flowers yielding great numbers of small fruits (achenes), remind us of its double means of propagation.

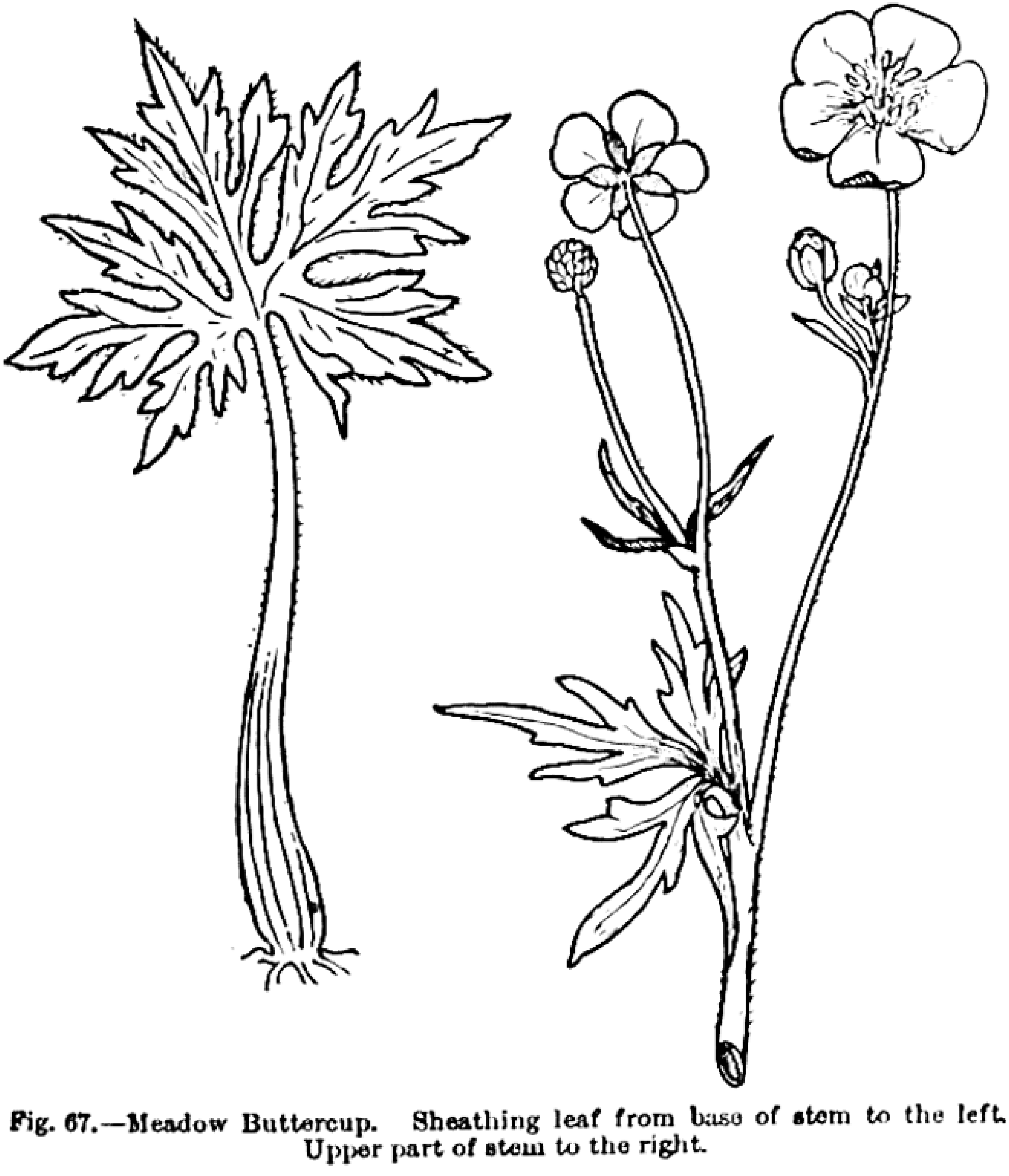

Fig. 67.—Meadow Buttercup. Sheathing leaf from base of stem to the left. Upper part of stem to the right.

As we look across the road to the open field close at hand we can see other buttercups. These are taller and quite evidently of a different habit. You know what these are, do you not? These are specimens of the **meadow buttercup** (*R. acris*), which you see is different in several particulars. Note the erect habit, enabling the plant to compete with the long grasses amongst which it is growing. Then we observe there are no rooting stems here, the leaves are more deeply cut into, and the flower stalk is plain, whereas that in the creeping buttercup you can see is grooved (Fig. 67).

We are fortunate in finding to-day a third buttercup, for here, at the lower end of the same field, is the **bulbous buttercup** (*R. bulbosus*). It is not so tall as some of the meadow buttercups, but apart from that it is readily recognised, first by its sepals being turned back from the flower, and by the swelling at the base of the stem. It will repay you to take these three buttercups home and go over them in detail, noting the differences distinguishing the three species.

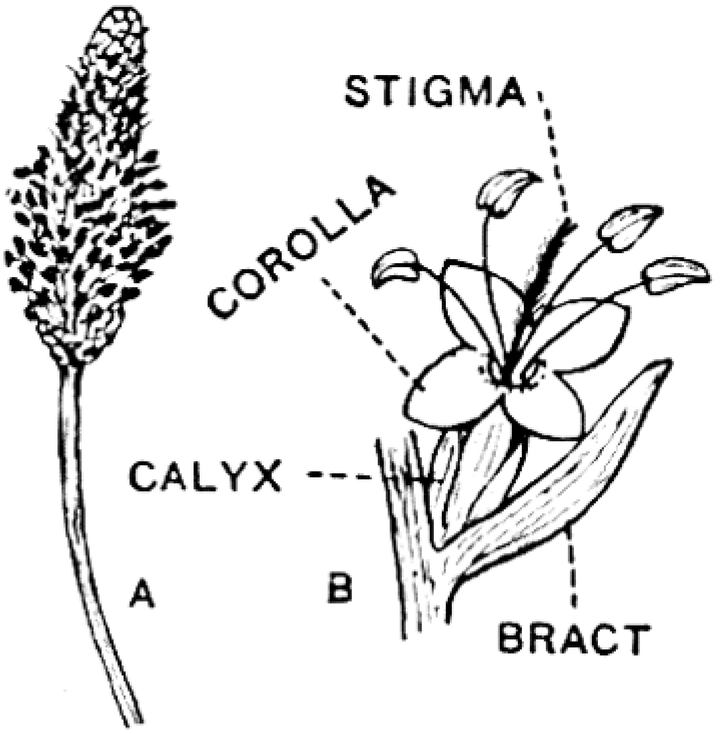

Fig. 68.—A, Spike; B, Flower of Plantain.

In the upper portion of the spike the anthers are not yet mature, but the stigmas may be seen extended.

Turning once more to the roadway we find just fringing it stray plants of the **lady's mantle** (*Alchemilla vulgaris*). Note the beautifully formed leaf, with its regular folding and toothed margin, each tip bearing a fine hair tuft. These small yellowish-green flowers you can see have a clearly marked shiny ring just inside the corolla. The flowers are cross-fertilised by means of small insects which are attracted by this ring. In some of the faded flowers we find the fruit (an **achene**) still lying within the dry calyx tube.

A little way back, in the deeper shadow, note this plant with the somewhat coarse hairy stem, large pointed leaves, and somewhat unattractive-looking flowers. This is the common **comfrey** (*Symphytum officinale*). The flowers are worth examining for a moment. Note how the inner part containing the pollen and nectar is shut off by means of five converging scales forming a "pollen box." This keeps out the smaller creeping insects which would be apt to rifle the flower without effecting cross-pollination. The flower is adapted to pollination by bees, which are able to push aside the scales. On this flower one sometimes finds small holes at the base made by bees with too short a proboscis attempting to reach the nectar from the outside.

Here is plenty of **common sorrel** (*Rumex acetosa*) all along the wayside, known in Scotland as " sourocks," and whose leaves, having a pleasantly acid taste, are frequently eaten by children. Another member of the same group quite near at hand, although not common here, is the **curled dock** (*Rumex crispus*), which we distinguish from the **common dock** (*R. obtusifolius* by its leaves being very wavy or curly along the margins. Still another member of the same Order is this not unattractive-looking weed, with its short pinkish clusters of small flowers, the **spotted persicaria** (*Polygonum persicaria*). Note the curious black-looking blotch upon its leaves, from which the name " spotted " is derived.

Fringing the other side of the roadway, we note here and there **white clover** (*Trifolium repens*) and **bird's-foot trefoil** (*Lotus corniculatus*), common plants, but not to be overlooked—add their names to your list.

On the same side of the roadway, which is the sunnier, we find a good many specimens of the common **goutweed** (*Aegopodium podagraria*), which you may distinguish from other plants of the same Order (Umbelliferae) by its large twice or thrice ternate leaves and smooth, grooved, hollow stem. Note the grouping of small white flowers into conspicuous inflorescences (umbels). Here also we find another of these Umbelliferae ; this is the **hogweed** or **cow parsnip** (*Heracleum sphondylium*). Notice the grooved hairy stem, and large lobed leaves with the sheath of leaf stalk very large.

We turn now off the main roadway, along a narrow path leading down to the banks of a narrow stream. Here at our feet are some fine long-stalked **ribwort plantains** (*Plantago lanceolata*). Let us look at them for a moment. Notice that we can recognise three stages of the flower upon these spikes.

Beginning at the top, observe that the separate flowers of the spike (which are the youngest ones) show their stigmas protruding, but the stamens are not yet visible. Below these, forming a circlet around the spike, is a set of flowers, whose stamens are now extruded, and, with their **versatile anthers** nodding in the wind, are shaking out their pollen, to be carried to younger flowers whose stigmas are mature. The stigmas in these flowers with ripe anthers are now withering (Fig. 68).

The lowest portion of the spike consists of flowers now in the fruiting stage; anthers and stigmas both are withered, and seed is forming. You can see from these things that the flowers of the plantain are protogynous (that is, the stigmas are ripe before stamens), and they are wind-pollinated. Notice also the mosaic of radical leaves well shown in this species.

As we pass along we notice several small plants with yellow flowers. The first of these has the flowers in small rounded clusters (capitula). It has small trifoliate leaves, the leaflets of which you observe are narrow at the base and broad towards the tip, which is quite clearly shown as a little tuft. This is the **black medick** (*Medicago lupulina*). When in fruit it has small black, curved, wrinkled pods.

Here, close at hand, is another plant of the same order, the **meadow vetchling** (*Lathyrus pratensis*). Its flowers are also yellow, but larger, and the inflorescence is more open (a raceme). Notice the angled stem, the long narrow leaflets (lanceolate), and the very large stipules.

The **germander speedwell** (*Veronica chamaedrys*) and the **ground ivy** (*Nepeta glechoma*), this pinkish white flower growing along the edge of the path, **yarrow** or **milfoil** (*Achillea millefolium*), **cat's ear** (*Hypochaeris radicata*), and **ox-eye daisy** (*Chrysanthemum leucan-*

themum)—all of them familiar wayside flowers—we find well represented.

On our right we now find a widely-extending and steeply-sloping bank, with an open exposure southwards. Here the vegetation is very tall, **broom** (*Sarothamnus scoparius*), **gorse** (*Ulex europaeus*), surrounded by tall grasses, amongst which we recognise the **Yorkshire fog** (*Holcus canatus*), are well represented. Notice the **blackberry** or **bramble** (*Rubus fruticosus*), how it is bending to form a thicket-like barrier to the bank. Here alongside is the **dog rose** (*Rosa canina*). Notice the uniformly-sized hooked prickles with expanded base, and the absence of glandular hairs upon the leaves, distinctive features of this species.

Behind these shrubs, on the more open parts of the bank, are plenty of **black knapweed** (*Centaurea nigra*) and **ragwort** (*Senecio jacobea*). That tall thistle is the **spear thistle** (*Cnicus lanceolatus*). Note the firm winged stem and strong leaves, both with long and sharp spines. Observe also the long, firm spines upon the bracts surrounding the somewhat pale, purplish heads.

What is this tall, slender plant with spike of small yellow flowers? This is **agrimony** (*Agrimonia eupatoria*). Observe how few flowers on this long spike are open. The flowers of this plant bloom for one day only. Each has a false nectary, a fleshy ring at the base of the styles, which does not form nectar, but which may cause insects to alight upon the flower and in so doing effect pollination. The plant appears to be self-pollinated chiefly, and to have few insect visitors.

Here is another tall plant with yellow flowers, grown somewhat bushy, with stiff, erect branches, and small opposite leaves. This is the **perforated St. John's wort** (*Hypericum perforatum*). The various St. John's wort species are somewhat difficult to distinguish. Notice here the smooth, two-ridged stem, the glands on the sepals, and the long styles. Hold the leaves up to the light, and note the clear spots characteristic of this and other species.

On our left hand our view of the stream and its banks has been largely interrupted by the **hawthorn** and other bushes.

We come now to a more open part, and here we note several interesting species. Do you know these tall, waving, soft, downy-looking plants with pink flowers, growing in great luxuriant masses close to the water's edge? This is the **great hairy willow herb** (*Epilobium hirsutum*). Notice the fine big flowers with the very long ovary (Fig. 69) and large, hairy, lanceolate, opposite leaves. These are handsome plants, evidently growing in a suitable place. Notice that they are nearly all upon the sunny side of the stream.

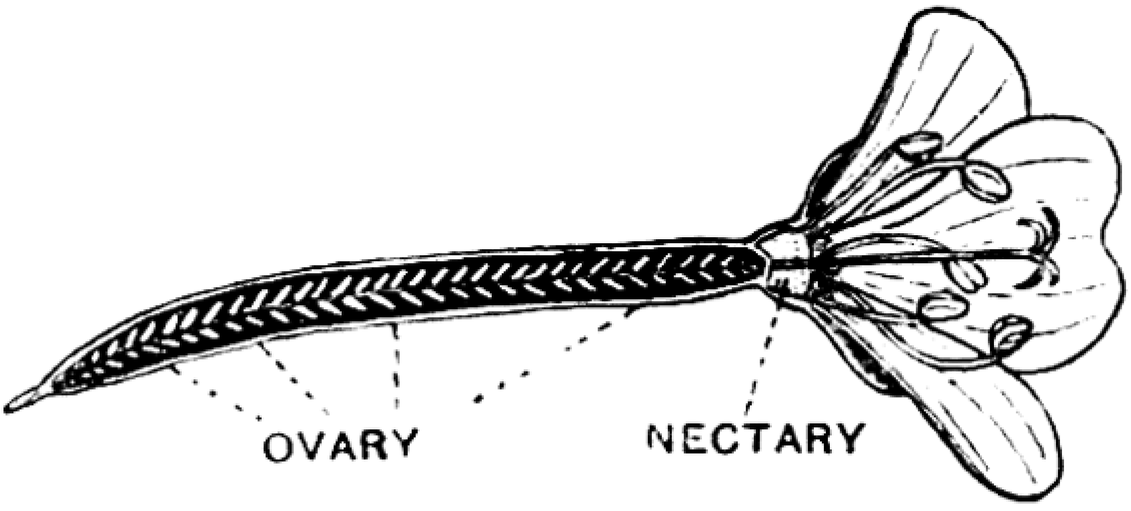

Fig. 69.—Half-Flower of Species of *Epilobium*.

Here is another attractive find for us, a solitary specimen, also growing quite close to the edge of the stream, What plant is this with the large rounded leaves, firm erect stem, and small brownish green flowers? This is a figwort. Notice, however, this is not the common knotted figwort, but the **water figwort** (*Scrophularia aquatica*). Observe the four distinct wings upon the stem characteristic of this species. The figwort is interesting in being pollinated by the agency of wasps. Here, too, is the **water avens** (*Geum rivale*), with its drooping, brownish looking flowers.

Note yonder, on the opposite bank, in more shady situations, clusters of the beautiful **meadow cranesbill** (*Geranium pratense*). This handsome blue flower is one of the prettiest of the cranesbills.

The bank on our right has now become more level, and here, amongst shorter grass and clovers, we find a rather pretty, delicate-looking plant, the **mouse-ear hawkweed** (*Hieracium pilosella*). Note the pale lemon colour of the dandelion-like heads, and leaves with downy hairs. Here also we find the **hop trefoil** (*Trifolium procumbens*), which you should compare with the black medick already seen. Both have small heads of yellow flowers and trifoliate leaves. The readiest way to distinguish these is by their fruits. Here is the hop trefoil in fruit; note the cluster of small pods enveloped in the scale-like corollas, quite different from the kidney-shaped black wrinkled pods of the medick.

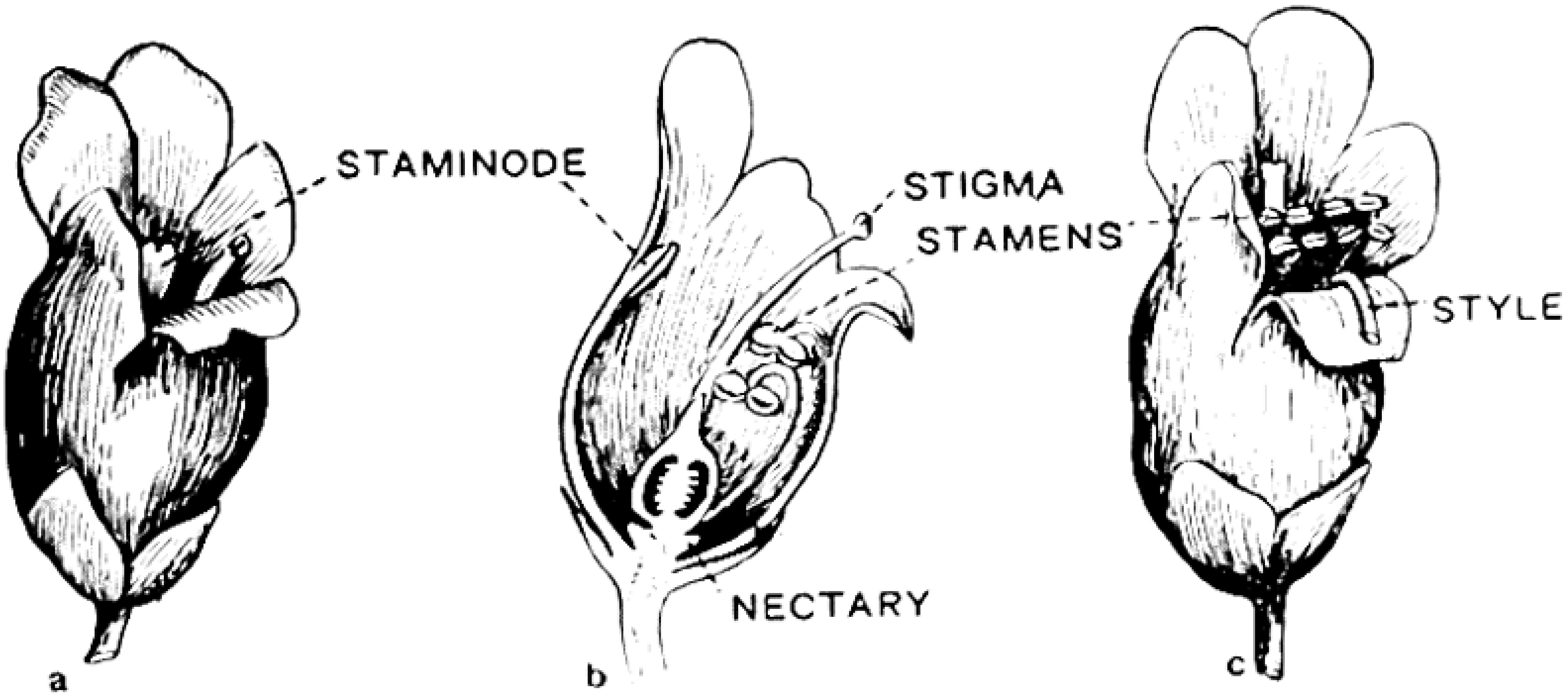

Fig. 70.—Scrophularia nodosa (Figwort).

a, Flower when first opened; b, Longitudinal section of same; c, Flower day or two later. In c the style and stigma are now withering, while the anthers are exposed and about to open.

Passing onward a little way, we find the bank becomes steeper and the herbage thicker. Here occurs a large patch of **butter-bur** (*Petasites vulgaris*), recognised by its very large leaves, which all through the summer build up stores of food for use the following spring. This is one of our early spring flowers. Just beyond this patch we find again large quantities of the perforated St. John's wort, and this time the **knotted figwort** (*Scrophularia nodosa*), whose stem we are able to compare with that of the water figwort (Fig. 70).

Here, too, are the **red campion** (*Lychnis diurna*) and **white** or **evening campion** (*L. vespertina*), growing quite near to each other. Notice that two kinds of plants occur in each case, one bearing stamens ten in number, and another bearing the ovary with its five stigmas. Notice that the flowers of the white campion have their petals drawn close together. This flower is fully open only in the evening, when the moths which visit it are about. A good many of these have been pollinated and the fruit is formed, Note the dried brownish capsules with their toothed margins. On examining an open one we find the seeds grouped in a ball-like arrangement in the centre, quite clear of the walls (free central placentation).

Here is another interesting find. On opening a not quite ripe fruiting capsule of this same plant, a remarkably active caterpillar is discovered. It is brown in colour, and has beautiful diagonal-shaped markings along the sides. This insect (*Dianthoecia capsincola*) spends its caterpillar existence in this dark prison house; when the capsule opens the moth into which it is transformed is free to fly away.

A little farther on we come upon a single tuft of the **rest harrow** (*Ononis arvensis*). This interesting leguminous plant has all its stamens united in a tube, and although without nectar, is visited by insects. Like the bird's-foot trefoil, it has a piston arrangement of the stamens for extruding pollen from the tip of the keel when this part is weighted down by the body of the visiting bee.

Here we observe in the bed of the stream some examples of the interesting plant known as the **bur-reed** (*Sparganium ramosum*). Notice the long sword-shaped leaves, branched stem, and globular flower heads. Of these there are two kinds; the upper smaller ones, you observe, consist of stamen-bearing flowers (male flowers), and the lower and larger heads of flowers bear ovaries (female flowers).

Another aquatic plant we observe is the **amphibious persicaria** (*Polygonum amphibium*). Note the smooth, glossy, floating leaves with long stalks, Compare this plant with the spotted persicaria found earlier. It should be remembered that the appearance of the leaves and stem of the amphibious persicaria varies a good deal, depending upon whether the plant is actually growing in water or on land.

We have now reached the place where our pathway leaves the banks of the stream, and at this convenient point the present excursion may end. Within a comparatively short space a large variety of wild flowers have been observed. You must try to remember the appearance of as many of them as possible, and some of the things we have been able to note about them. We shall take another opportunity of reviewing what we have learned.

LESSON XXX.

NOTES ON A CLASS EXCURSION.

[The plants collected at the excursion should be kept in the vasculum in a cool place until required. They will easily keep, for some days at least, sufficiently fresh to permit of identification. In addition to the suggestions noted below the class might be given short lessons on some of the plants whose particular features are pointed out in the previous lesson.]

We have before us specimens of the plants which we gathered at our last excursion. The first thing we wish to do to-day is to go over their names so that we may see how many we remember. Some of them, of course, we knew before and these are readily recognised, others are less familiar. The best way for us to proceed will be for the teacher to exhibit each plant in turn and ask you to name it. Only in some cases shall we at this stage ask you for the marks by which you recognise it. As we name the plants they will be handed round the class so that each pupil may get a look at them close at hand.

As they are named and examined you must compare your list made at the excursion and revise any notes you took at the time. With all plants which are new to you it will be best **not to try to remember a great deal** about them, but it will be a good thing if you can picture for yourselves in each case the **situation in which you saw the plant growing** and remember its general appearance, and perhaps one distinguishing thing about it.

Another interesting thing we can do in revising our list is to group those plants together which more or less resemble each other. In doing this it will be best for us not to attempt this grouping with all our plants, but only with those which are easiest for us.

The first flower we noted at our outing was a buttercup, and of these we have three kinds in our collection. This constitutes our first group. We shall call these groups by the name of Orders. This is the Ranunculus Order.

Ranunculaceae—

Creeping buttercup.
Meadow buttercup.
Bulbous buttercup.

You can see that these plants all have the parts of the flower separate from each other, five sepals, five petals, a very large number of stamens, and carpels numerous also. There are other buttercups besides these, and in this same Order are some other flowers you know, such as the Christmas rose (which is not a rose), the marsh marigold, the wood anemone, monkshood, and several others.

Our two campions form another group, the Pink or Chickweed Order.

Caryophyllaceae—

Red campion.
White or evening campion.

This Order has a number of readily recognised characters. Look how the leaves are arranged in pairs crossed at right angles to each other. They are simple, and the stem is generally thickened at the nodes. The flowers are radial in form, sepals and petals five each, stamens ten.* The ovary has a single cavity with the ovules in the centre (we observed this in the campions). Familiar members of this Order are chickweed and stitchwort.

Our next group is a little more difficult. It will be best for us in this case simply to place the members together. As we go on studying flowers we shall gradually learn why they are brought together into one group—the Rose Order.

Rosaceae—

Bramble.
Water avens.
Agrimony.
Lady's mantle.
Dog rose.

The flowers of the bramble or dog rose are the simplest and these might be examined (Figs. 71, 72).

An interesting and important group is that of the Pea Order.

Leguminosae—

Gorse.
Broom.
Clover.
Hop trefoil.
Medick, black.
Rest harrow.
Bird's-foot trefoil.
Meadow vetchling.

All these plants have flowers of the pea type, with the fruit a pod. Their leaves are compound and possess stipules. You have studied the structure of some of them in other lessons. Meantime you will not find it difficult to recognise any new forms belonging to this Order.

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* The campions in having male and female flowers are not typical of the Order.

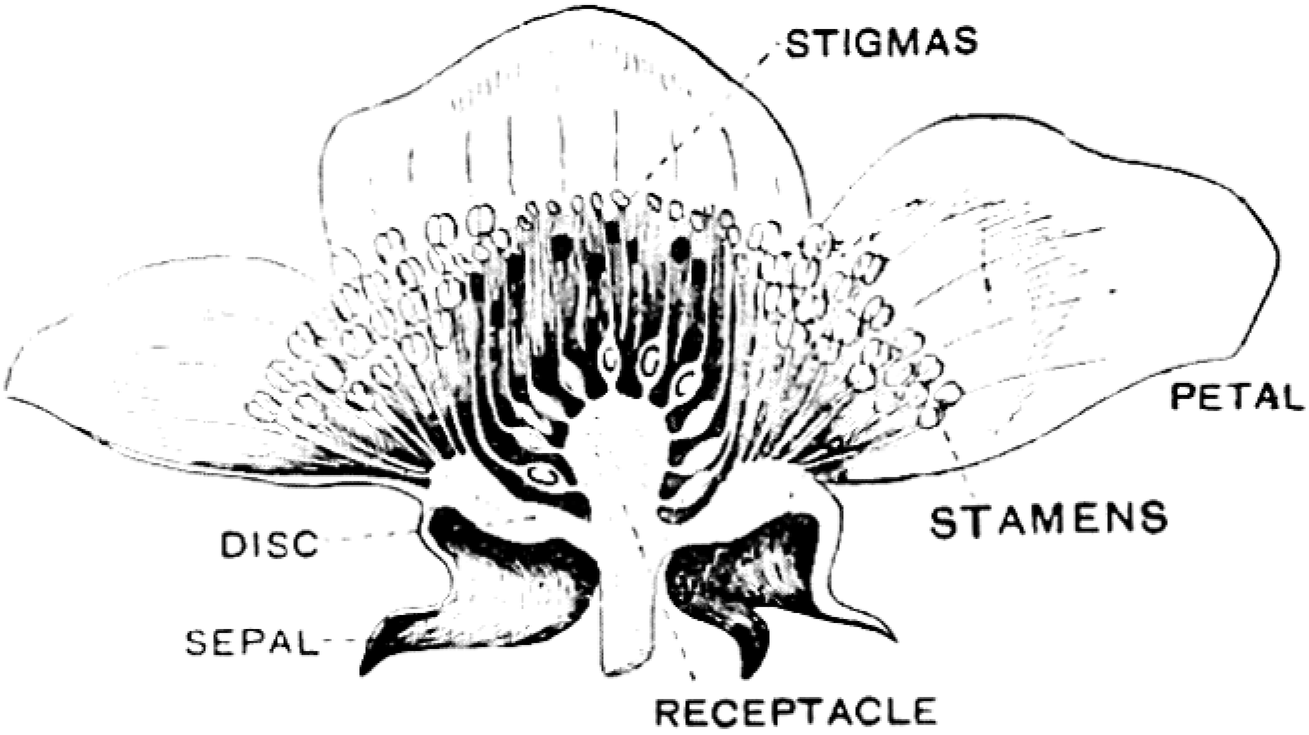

Fig. 71.—Half-Flower of Blackberry

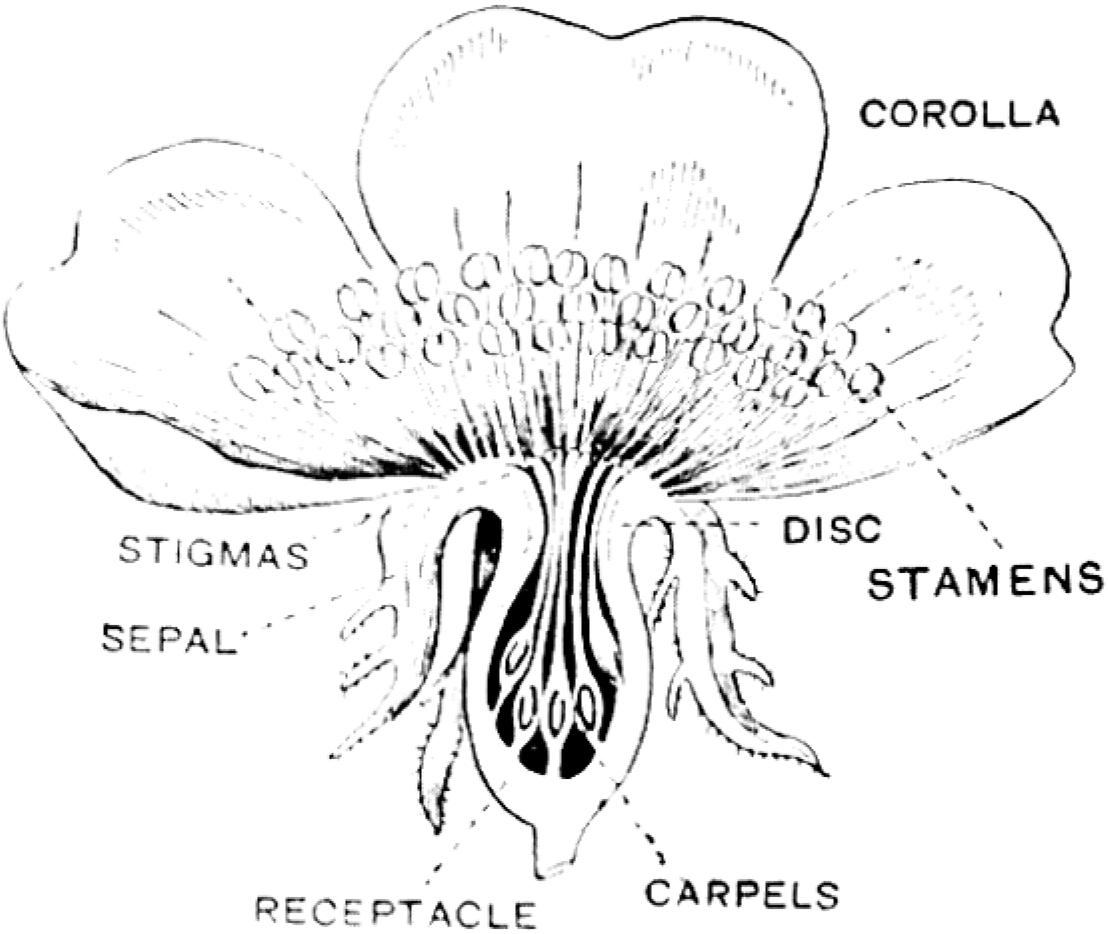

Fig. 72.—Half-Flower of Dog Rose.

A group which includes many common plants is that known as the Compositae. We have a number of these upon our list.

Compositae—

Cat's ear Mouse-ear hawkweed	Flowers strap-shaped and having carpels and stamens. Plants with a milky juice.
Spear thistle Black knapweed	Flowers tubular. No milky juice.
Ragwort Ox-eye daisy Yarrow	With strap-shaped flowers arranged radiately, and tubular flowers in centre. No milky juice.

In all of these the flowers, which are small, are grouped into close set clusters (capitula or heads), each cluster having a superficial resemblance to a single flower. The name Compositae refers to the composite nature of the flower head. In your lessons on the dandelion and daisy you have learned about this and also understand why we group the foregoing plants in three sub-divisions, as above. But you might now, in revising, distinguish what are termed strap-shaped florets and tubular florets. Notice that in yarrow the flower heads are small and grouped close together so as to make a conspicuous compound inflorescence.

Our next group consists of three interesting plants, belonging to the Foxglove Order.

Scrophulariaceae—

Germander speedwell.
Knotted figwort.
Water figwort.

This is a rather difficult group, and we shall at present simply note that these flowers are to be classed together. The plants of this Order are mostly of striking appearance, the flowers are bilateral and most of them show peculiarities in relation to the visits of insects. Can you name any other common flowers which belong to this Order? Foxglove, antirrhinum, eyebright, yellowrattle are a few.

We have already studied particular examples of this Order so that we now understand better the meaning of their striking form (pp. 148, 156).

There is another very useful way in which we ought to group the plants we see growing out of doors. That is according to the kind of situation they grow in. I think you have already noticed certain plants which grow mostly by waysides. You will soon begin to notice, too, others which are generally found in damp situations, and never in dry places. From what you saw on your last excursion, you should be able to answer the following questions:—

Name six common wayside plants.

In what kind of surroundings have you seen the following plants growing?—Meadow buttercup, bur-reed, great hairy willow herb, yarrow, water figwort.

Name a peculiarity of the red and white campions.

Distinguish the bulbous buttercup from the meadow buttercup.

Describe the fruits of the black medick and the hop trefoil.

How do you recognise the spotted persicaria?

In the ribwort plantain whether are stigmas or anthers ripe the earlier?

What kind of insect pollinates the figwort?

GENERAL CHARACTERS OF THE NATURAL ORDERS

of the Flowering Plants (other than Trees) studied in the foregoing Chapter.

[For explanation of Botanical Terms see Glossary.]

Leguminosae.—See p. 171.

Sarothamnus scoparius	**Broom**
Ulex europaeus	**Gorse**
Trifolium repens	**White clover**

Compositae.—See pp. 139, 173, where several familiar examples are referred to, and the chief flower characters of the Order are given.

Taraxacum dens leonis	**Dandelion**
Bellis perennis	**Daisy**

Scrophulariaceae.—The flowers in this Order possess petals and sepals each united at the base into a tube. The corolla is frequently two-lipped, and is more or less clearly bilateral (zygomorphic). The stamens consist of two pairs of unequal size or one pair, rarely five are present (epipetalous). Ovary superior, consisting of two united carpels. Fruit a capsule. Leaves alternate or opposite, without stipules. Herbs mostly.

Various examples of this Order have been already quoted (pp. 148, 156, 173).

Digitalis purpurea	**Foxglove**
Veronica chamaedrys	**Germander speedwell**

Labiatae.—The plants of this Order are usually readily recognised by the bilabiate corolla (zygomorphic), the rectangular stems, the opposite and decussate leaves, and the apparent whorls of flowers at the nodes. The flowers have petals and sepals each united at the base into a tube. There are four stamens, in two pairs, the fifth being absent. The ovary is superior, consisting of two united carpels, in which two false septa arise in the formation of the fruit. Each division of the ovary contains a single seed.

Lamium album	**White dead-nettle**

Other familiar flowers of this Order are *Prunella vulgaris*, **self-heal**; *Nepeta glechoma*, **ground ivy**; *Thymus serpyllum*, **wild thyme**; *Mentha*, sp. **mint**; *Stachys*, sp. **woundwort.**

QUESTIONS ON CHAPTER III.

(SUMMER: PLANT STUDIES.)

1. Name six common leguminous plants.

2. How can you tell flowers of the broom which have been visited by bees? What do bees get in this flower?

3. Make a diagram of the flower of the broom, naming the parts.

4. Some leguminous plants have ten stamens united together into a tube, and others have nine so united and one free. What other feature about the flower is this related to?

5. What is a "capitulum"? State some advantages to clover plants in possessing flowers grouped in this way.

6. Give some illustrations of "movement" in plants.

7. In what ways are clover plants spread?

8. Describe fully a clover leaf.

9. Make a drawing of what you see in a surface view of the germander speedwell flower. How many stamens has this flower? How are they placed? What kind of insect visits it?

10. Describe a floret of a dandelion.

11. Describe a dandelion leaf and state what advantage its particular form possesses.

12. Apart from shape and colour what other difference exists between the ray and the disc florets in the daisy?

13. What are the special advantages of the form and arrangement of the flowers as seen in the Compositae?

14 Make a drawing of a single dandelion fruit. How many seeds does it contain?

15. Make a drawing of the leaf of the elm, horse-chestnut, and sycamore.

16. Distinguish between simple and compound leaves. Give examples of each.

17. What is a leaf mosaic? What purpose does it serve?

18. What is the general appearance of the bark of the beech, ash, black poplar, or of any other three trees?

19. How is it that the under sides of leaves are generally lighter in colour than the upper? What are stomata?

20. What provision is made in the white dead-nettle flower to keep off from the nectar undesirable insects?

21. Describe the process of pollination in the white dead-nettle flower.

22. Make a drawing of a foxglove flower in section, showing the principal parts.

23. What arrangements exist for avoiding self-pollination in the foxglove? What is the advantage in the flowers all looking the same way, in drooping slightly, and in having a narrow neck near the base?

24. What is a biennial? Give examples.

25. Name three common buttercups, point out their principal differences in structure and in habitat.

26. What are the general characters of the flowers of ranunculus? Name a few other plants belonging to the same Order.

27. Name an important characteristic of the flowers of white and red campion. What kind of insect pollinates the white campion?

28. Give examples of three different kinds of flower of Compositae. Name some examples with a "milky" juice (latex).

29. Name three flowers of Leguminosae which do not possess nectar.

30. When does the butter-bur flower? In what condition do you find the plant in summer?

31. How is the plantain pollinated? What adaptation exists in the stamens in relation to the mode of pollination?

32. What relations exist between buds and leaves upon a plant? How can you tell a compound leaf from a branch with small leaves?

33. What are lenticels? What purpose do they serve?

34. Name some flowering plants you are likely to find by the banks of a stream or growing in it.

35. Name ten common roadside plants.

36. Describe the appearance in summer of any common tree in which you are interested.

CHAPTER IV.

ANIMAL STUDIES IN SUMMER.

LESSON XXXI.

THE HEDGEHOG (*Erinaceus europaeus*).

[Specimens are not difficult to obtain in the country and can easily be purchased in town quite cheaply from animal dealers. The animals may be kept without much trouble for a day or two. They tame easily, and then are most conveniently used for study in school.]

Where it lives.—Here is a familiar animal in many parts of the country. What is it called? The Hedgehog; less commonly, perhaps, it is also known as the Urchin. Where may it be seen usually? In woods, or by hedge banks—generally in places where the vegetation is not very short. It may be met with amongst ferns, fallen leaves, long grasses, and such like.

When it may be seen.—At what time of the day is it most likely to be found away from its hiding place? Throughout the night or in the quiet of a summer evening. The hedgehog, like most of our wild animals, has learned that night is both the safest and the best time in which to find food. It is a **nocturnal** animal. At what season of the year do we usually find it abroad? The summer is its most active time, because then is the time when its food is most plentiful. It is then, too, that there are young hedgehogs to be tended and fed.

Food.—What is the food of this animal? I hope you have seen it feeding. It takes a great many different things, from beetles to adders, pheasants' and other birds' eggs, as well as young birds. Slugs and worms are also included. And if you have ever kept a pet hedgehog you will know that it takes bread and milk readily. It is also very fond of ox liver. So you see they are liable to vary their diet very much.

Disposition.—What is the disposition of the hedgehog? It is a **timid** animal, but one which very soon—especially when kindly treated—gets over its timidity. None of our native wild animals tames so readily.

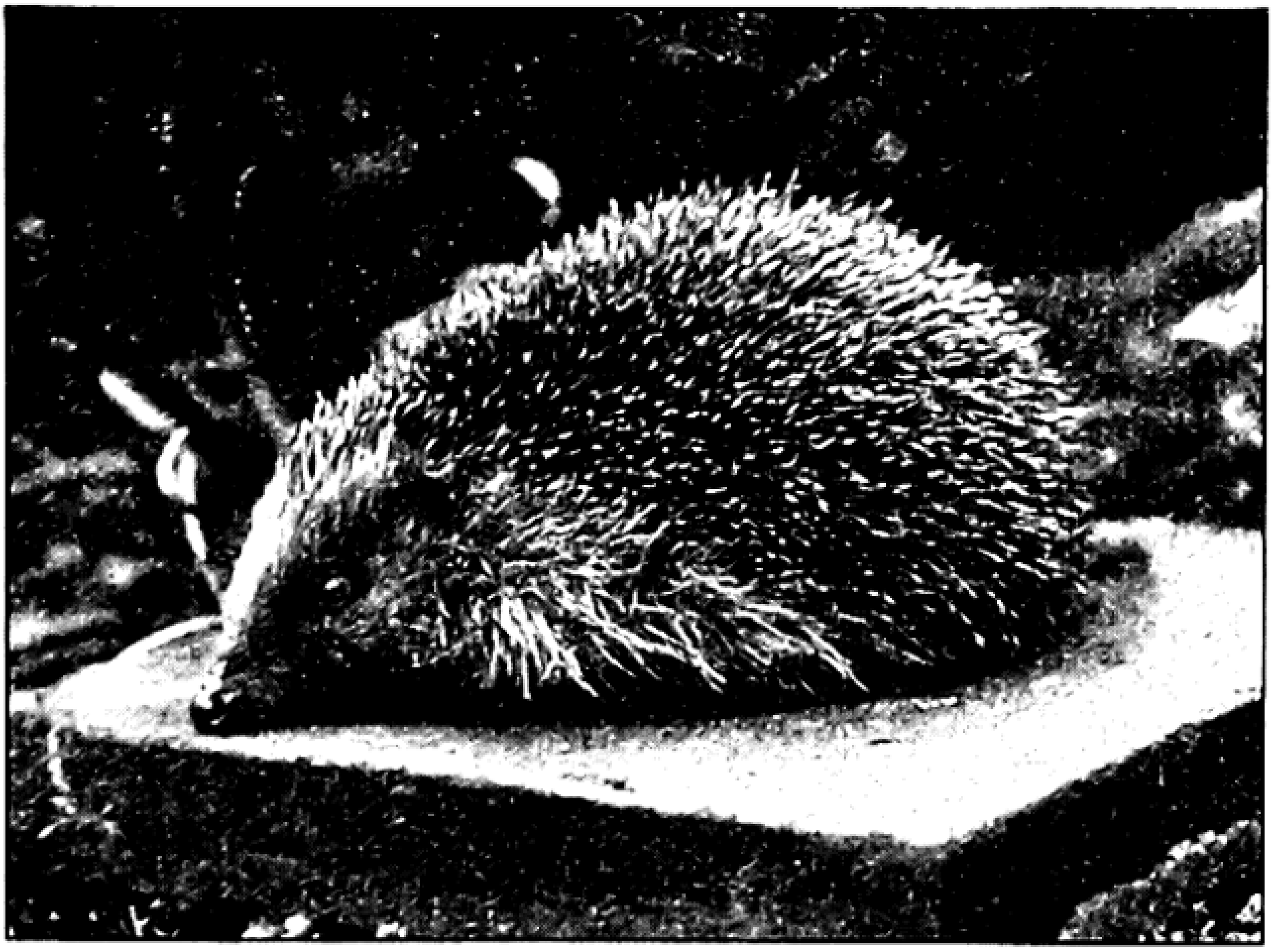

Fig. 73.—The Hedgehog.

Description.—Have you looked at the hedgehog closely? Of course, if it is quite wild, unless you keep quiet and do not touch it, you cannot do so. This is because the hedgehog when disturbed or alarmed does not run off, but **curls itself** into a ball and remains quite still. Then of course the only thing one can see is its sharp spines.

But if the animal is left alone we soon get a good view. Look at the animal here. You must make a drawing of it (Fig. 73). As you do that you will discover the following things. Write down your observations thus:—

The strong sharp **spines** cover the whole of the back, sides, and top of the head.

The under parts, as well as the whole head except the muzzle, are covered with strong **bristly hairs.**

The tail is very short, so also are the legs, which are quite black. The whole of the hind feet from the heel forward may rest upon the ground. The **claws** are long.

The snout is black and tapering; the eyes are not very large; the ears are short and rounded, and the mouth has **strong teeth,** which are also very sharp and pointed.

Protective Arrangements.—If we ask the question: **Why is this animal spiny?** the answer is in this case very easy to give. We can always see the use the animal makes of the spines, and how valuable they are to it. They form a very complete means of protection from attack when the animal rolls up. We have seen that the hedgehog attacks other creatures—mostly small and weak and defenceless—although this is not so in the case of adders. It is, however, a hunter which needs protection from other hunters in turn. Can you name any animals which are **enemies of the hedgehog** and would eat it if they could get at it? Foxes, stoats, and dogs all try it, but they do not always manage to kill it.

Animal Defences.—There are three things we might notice here. One is that some animals are much better protected than others. Moles and shrews belong to the same group as the hedgehog. The mole, of course, is safe from most enemies whilst under ground in its burrow, but the shrews are very defenceless. Neither of them is so well provided against attack as the hedgehog is. Indeed, no other animal in this country has so good a defence.

Notice, too, the more usual means of defence. Hunted animals, such as rabbits and hares, are equipped with keen senses, especially of hearing and smell, so that they become warned in time of the approach of an enemy, and with fleetness of foot, so that they can run as soon as they are warned. So also are the deer upon our hills. Squirrels are protected by living in trees and having considerable powers of leaping amongst the branches from tree to tree. Rats, mice, and voles show no particular defences, and many succumb to beasts of prey. This is compensated for in their case by their numbers being rapidly replaced.

Other Spiny Animals.—Notice some other cases in which a spiny coat is a protection. There is the Echidna or **spiny ant-eater** of New Guinea, the **tenrecs** of Madagascar, allied to the hedgehog, but larger, and the **porcupine** occurring in Spain, Italy, and North Africa. The porcupine erects its spines when alarmed. But there are remarkably few spiny animals.

The Nature of the Spines.—How has the hedgehog got its spines? They are formed from the bristles. If you look at the sides of its body where spines and bristles meet you will find plenty which are intermediate between both. Have you ever seen young hedgehogs? On these the spines are very soft and whitish to commence with, but they soon become hard.

Hibernation.—What does the hedgehog do in winter when food is scarce and the weather is cold? It feeds well in summer and autumn and goes into a deep sleep in winter. This is one of the most successful ways which animals have of solving the problem of winter (see p. 394).

The mole and the hedgehog are members of the Class of animals known as Mammalia. Their bodies are warm like those of birds—contrast, for example, snakes, frogs, or fish (cold-bodied)—and they suckle their young with milk. Mammals are the only creatures which do this.

I am sure you can name at least a dozen wild mammals of our own country.

Similar lessons may be given upon other common mammals, *e.g.* stoat, weasel, squirrel, water vole (p. 329). The teacher should consult *Aims and Methods of Nature Study*, p. 137, for notes upon stoats and weasels, etc.

LESSON XXXII.

PIGEONS.

[For the purposes of this lesson appeal may be made to living pigeons familiar to the pupils, either tame or wild. A stuffed pigeon if available will be useful in several ways; a live caged bird might be hired from a dealer for a few pence, or lent by a pupil.]

Most of us know something of this bird, either wild in the country or by the seashore or tamed in dovecots, as well as in the streets and squares of towns. The pigeon is a familiar bird in most places. There are of course different kinds of pigeon—many different kinds of tame pigeon, but four only of wild pigeons in Britain. Although the tame variety is the most familiar, we shall begin our study by naming the wild forms. What are they? They are the **wood pigeon,** the **stock dove,** the **rock pigeon,** and the **turtle dove.** Let us ask some questions about these.

The Wood Pigeon (*Columba palumbus*).—What are the names of the wood pigeon—for it has more than one?

It is called the wood pigeon because it nests in woods, perches on trees, and frequents these a great deal. Then it is called the "ring dove" because upon its neck there are two whitish patches, partially encircling it like a ring. It is also called the Cushat or Quest, and in the north "Cushie doo."

Appearance of Wood Pigeon.—What is the wood pigeon like? It is the largest of our wild pigeons. In colour it is greyish blue above, with the wings and shoulders brownish. The neck shows beautiful green and purplish red reflections, and bears the two white or creamy patches already mentioned. The breast has something of a rosy tint.

You often see these beautiful reflecting colours on common tame pigeons. This was what Tennyson was thinking of when he spoke of the "burnished dove."

Its Note.—I would like you to think of some other things you can recall about the wood pigeon. For example, have you not often heard its note? A soft, coo-roo-coo-cōō, with the last two drawn out. It is a very pleasant sound to hear coming from the woods, and has often charmed us. This is how Tennyson refers to this sound:

"From the woods
Come voices of the well-contented doves."

It is the "coo" of the pigeon which suggests contentment to the writer's mind.

The cooing note is one of the peculiarities of pigeons. In various forms they all possess it.

Its Nest and Eggs.—What is the next thing you recall about the wood pigeon? Its nest. What is it like? A rough loose platform of sticks gathered in the wood, placed amongst the branches of a tree some distance above the ground. Over the greater part of the year—March to October—the nesting period is prolonged. What are the eggs like? Pure white, two in number. This is another peculiarity of wild pigeons. They do not all build the same kind of nest, nor in the same kind of place, but they all lay two white eggs. Sometimes there are three, but that is quite exceptional. The whiteness of the eggs is interesting because of the usually open exposed kind of nest. There are very few wild birds which have perfectly white eggs, and these are mostly laid in hidden places or in covered nests. Examples are the owls, kingfishers, sand martins, and swifts. Think of the kind of nest in some of these cases and compare it for exposure of the eggs with the nest of the wood pigeon.

Young Birds.—Have you ever seen the young wood pigeons? They are very helpless, and blind till about the ninth day. Their parents feed them at first with a whitish substance which is formed from the lining of their crops and which is known as "**pigeon's milk.**" This habit is not peculiar to the wood pigeon, but is practised by all our pigeons. Later they are fed with softened food out of the crop.

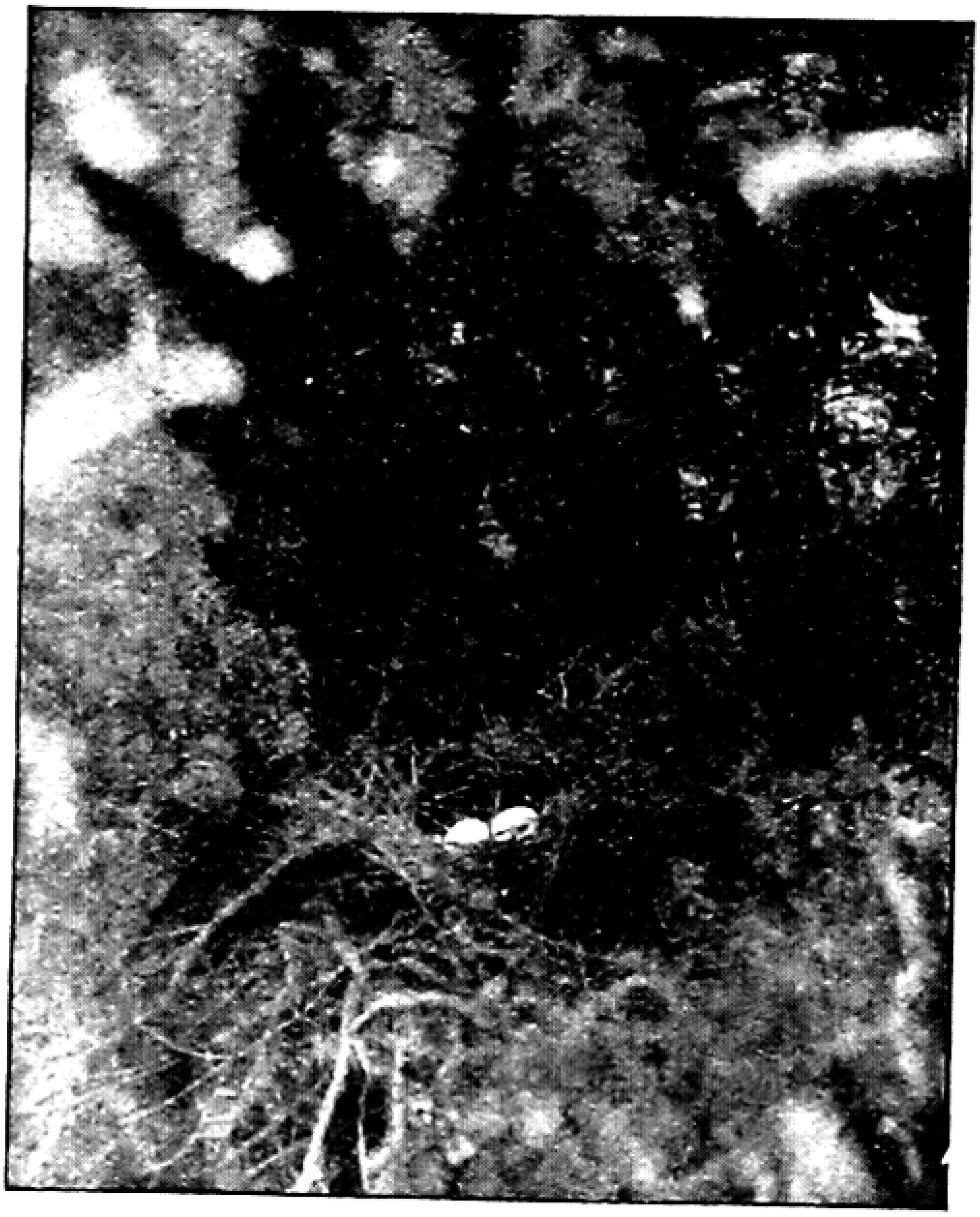

Fig. 74.—Nest of Wood Pigeon.

Habits.—Do you know anything about the habits of the fully grown birds? They are not liked by farmers for several reasons. What are those reasons? The first is that they take **nearly all their food from the crops** he grows. Grain, peas, clover, young turnip-tops are amongst the ordinary diet of wood pigeons. Amongst the seeds they take there are very few seeds of weeds. They take acorns and beech mast in abundance also. They scarcely take any insect diet. Another reason why they are disliked is that they not only feed on farm crops, but they eat enormous quantities; they have a very large crop and they always keep it very full.

Added to this is the fact that their **numbers are large.** Although the rule is two young to a brood they may have three broods in a year, egg-laying being sometimes continued on to October. But it is not so much owing to this that their numbers are great as that in winter very large numbers of pigeons arrive from the continent of Europe. Have you noticed that whereas during spring and summer the birds are seen living in pairs, in winter they feed in great flocks? Although they are shot in large numbers and kept down in various ways, their numbers do not seem to decrease.

Have you ever seen a pigeon drinking? If so you will have noticed that it takes a continuous drink with its head down, not an interrupted one like poultry for example.

Although fairly heavy birds, wood pigeons are strong, steady, and fast fliers. Watch them closely the next time you see them on the wing.

Rock Pigeons (*Columba livia*).—In many places along our coasts, where rocks and caves are common, another wild pigeon is sometimes found, viz. the rock pigeon. This is smaller than the wood pigeon. I would like to tell you one or two things about this bird. If you have never seen one, the next time you are at the seashore you must ask if rock pigeons live near, and, if so, go and see them. They are very pretty birds and nest in caves amongst the rocks.

Domestic Pigeons.—We are all familiar with tame pigeons. Perhaps some of you keep pigeons, or know some of the more popular varieties. Many of them are extremely strange in appearance, such as, for example, the long-legged, feathery-footed kind with enormous crop in front, known as **pouters.** I am sure you know the **fantails,** which have large outspread tails and thrown-back head. There are some varieties with strange-looking growths around the bill and eyes, the **carriers,** some with extremely short bills, or overhanging foreheads, others that "tumble" when they fly, **tumblers,** and others with ruffs or with "manes," and so on, besides various less grotesque-looking forms.

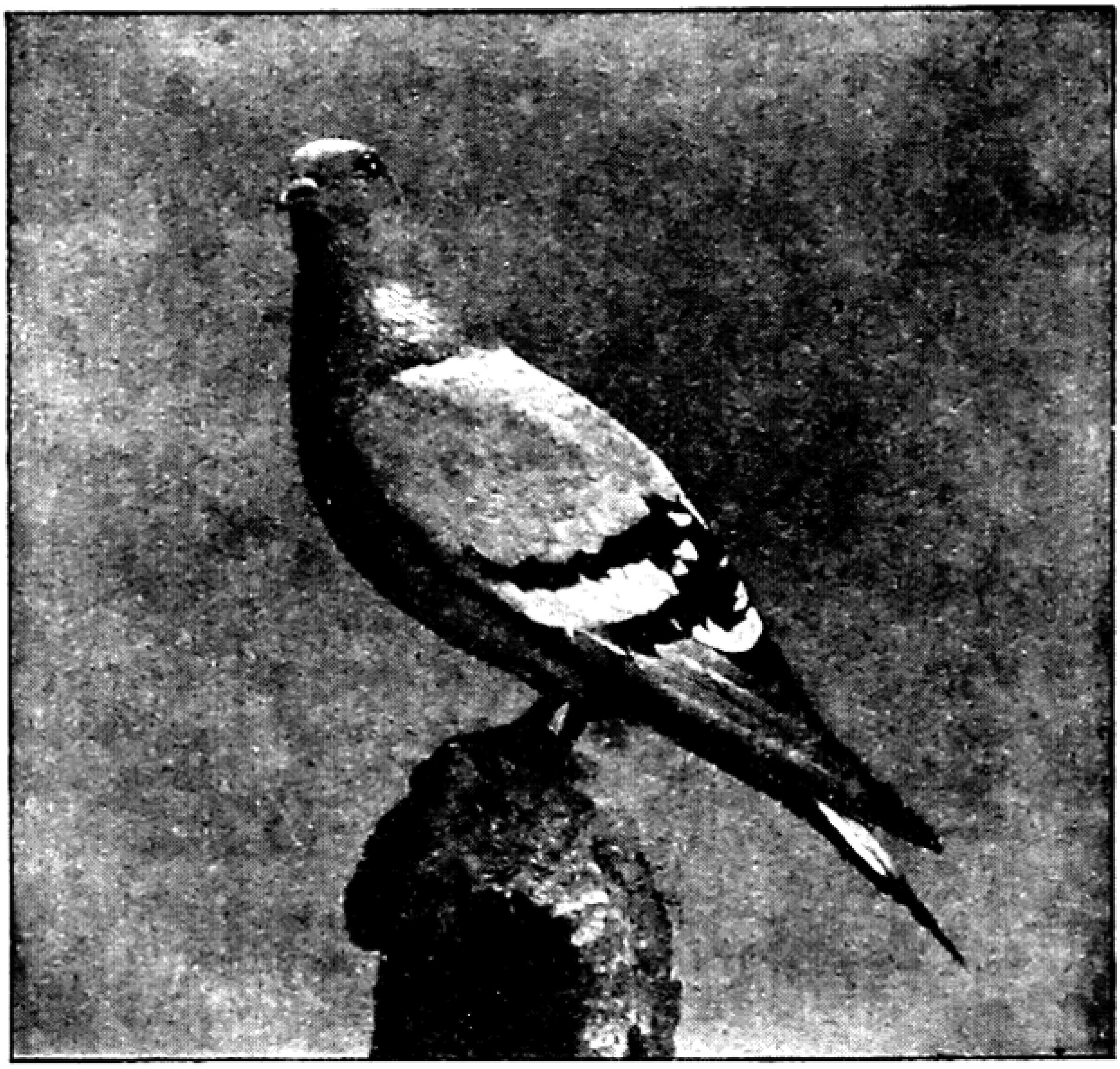

Fig. 75.—The Rock Pigeon.

How have all these strange looking creatures come to exist at all? The answer is: men have bred them from, in the first instance, the common rock pigeon we still know on the sea-coast as a wild bird. Perhaps you will learn something about the breeder's art when you are older. Meantime I want you just to think over the following:—

1. All tame pigeons have as their ancestors the wild rock pigeons.
2. The differences between them and the wild rock pigeon all arose naturally in the beginning.
3. Men have improved or increased those differences by rearing only particular birds selected by them.
4. When tame pigeons are allowed to go wild, such as those we see about towns, they lose to a large extent their special characters and become more or less like the rock pigeon, their far-back ancestor.

Marks of Rock Pigeon.—It will be interesting for you to look for the marks of the rock pigeon upon tame birds which are not specially bred, such as those to be seen wild in towns. The wild rock pigeon has the following marks (see fig. 75) :—

1. The green and reddish purple reflections on its neck.
2. A slaty blue colour generally.
3. A big white patch at the root of the tail on the upper side.
4. Two black bands across the wing.
5. A broad black band across the ends of the tail feathers.
6. The outer web of the outermost feather on each side of the tail is white.

The next time you have an opportunity of examining pigeons look for these marks. I think you are likely in a good many cases to find one or more of them.

The stock dove (*Columba oenas*) and turtle dove (*Turtur turtur*) are not so well known as the other two. The stock dove is somewhat like the ring dove, but smaller, and is without the "ring." The turtle dove is the smallest of the four. It is not a resident bird in Britain, but only a summer visitor to the southern and eastern counties mainly.

A familiar tame pigeon in dealers' shops called the turtle dove is the Barbary pigeon. It has a creamy plumage, with a narrow black band around the back of the neck. This bird is not found wild in our land.

You should write down the things you have been told are common to all our pigeons.

What are the names of our four British wild pigeons?

Name some common varieties of tame pigeons.

What are the "marks" of the rock pigeon?

Make a drawing of a pigeon.

LESSON XXXIII.

THE STARLING.

[The lesson may be given in districts where starlings are well known in the summer, and at a time when pupils can observe them for themselves out of doors. If a nest is known in the neighbourhood of the school, the comings and goings of the parent birds in search of food and the feeding of the young might be watched for a time. The eggs, if available, should be exhibited to the pupils. A stuffed bird, enabling the pupils to examine the plumage and other features, will be found very helpful.]

Recognition Marks.—Most boys and girls know the starling. We might begin this lesson by writing down shortly some of the things you know about this bird or have seen it do. Firstly, let us ask, in what different ways may you recognise the bird?

(*a*) **By its appearance.** What is it like? Have you not noticed a good deal of difference in the **plumage** of different birds even at the same time of the year? If we take the summer, for example, we notice some with dark, very glossy plumage, reflecting purple, green, and other colours with faint speckling on the breast, making the starling a rather handsome bird. Others again are duller and show on the breast larger triangular greyish specks. Do you know the meaning of these differences? The former is the male bird, the latter is the female. Sometimes in the summer you see the young birds. They are not spotted, but are greyish brown above, lighter below. The speckling varies through the year, wearing off during the winter.

Besides the plumage, what other points do you notice helping you to identify the starling? **Its bill.** This is yellowish in colour, long, angled, and spear-like. Have you seen the starling using its bill? If so you will understand the value to the bird of a bill of this shape.

The **shape of the bird** itself, and the way it sits too, is noticeable. The body is slender and tapering, about 8½ inches long, frequently inclined at an angle of 45 degrees or more from the ground, or from the perch; sometimes it is held almost erect. The legs and feet are reddish brown. The tail appears very short.

Draw from memory a starling in outline.

(*b*) **By its flight.** What is noticeable about a starling's flight? It is marked by rapid flapping of the wings. The flight is quick and hurried. Have you noticed the starlings flying in companies in the late summer? Their movements at this time are well worth watching. This is how the sight is described by Professor Newton: "The crowd, often numbering several hundreds, not to say thousands, of birds, wheels, closes, opens out, rises and descends as if the whole body were a single living thing—all these movements being executed without a note or cry being uttered." The sight is a very fascinating one. Have you seen it?

(*c*) **By its movement on the ground.** How does a starling move upon the ground? You may see it **walking** in a way which reminds us of the walk of the rook, or running quite quickly, but not hopping. On the ground it is keenly alert: you see it stop, stab its bill into the ground and pull out the insect grub or worm with rapidity and ease. Its behaviour on the ground is very characteristic. The best time to get a good look at the starling is in winter when it comes to be fed.

(*d*) **By its voice.** The chattering of the starlings, young and old, at the nesting time is well known. So too is the pleasant note of the cock bird. Starlings frequently nest about buildings, sometimes in unused chimneys, and then their chattering noises may become too familiar.

Habits.—What are some of the things we may see the starlings doing?

Early in the year (in the month of April) we may see them preparing a nest. Where have you seen starlings nesting? If you live in a town you may have seen them building about the houses, under the eaves for example. I know more than one school in which they regularly nest in a ventilator upon the roof. They also build readily in nesting boxes. But in the country away from villages they may build in holes in trees, or on the trees, in turf, or in crevices in rocks, and in various other places. The nest is very ordinary looking, showing no particular neatness, and with nothing special in its composition—straw, grass, twigs, moss, etc.

The Egg.—Can you tell a starling's egg at sight? It has two characters, making it readily recognisable. It is long and rather narrow in shape, about one and a quarter inches, and less than seven-eighths of an inch at its broadest part, and is of a **uniform pale greenish blue colour.** In a nest there are usually about five or six eggs, and sometimes there are two broods in a season.

Care of Young.—The starling is well known for the constancy of its care for its young. If you watch a nest in which young starlings are being reared and count the number of visits the parents make in an hour you will be surprised. Do you know what kind of food is brought to the young starlings? It is mostly insect food, with worms, slugs, and such like. One observer has seen a starling carry food to its young eighteen times in fifteen minutes (Board of Agriculture Leaflet, No. 45). Another (Newstead) counted

375 separate food items brought to a starling's nest by the parents in seventeen hours. Another observer (Read) counted about 270 visits by the parents in sixteen consecutive hours. Three birds were in the nest, the same bird was fed three or four times in succession, each getting their turn of feeding in this manner.

Have you ever seen starlings **upon the backs of sheep?** They may frequently be seen there. What are they doing? You will notice how the sheep seem quite pleased to have them. This is because they are feeding on the small wingless insects called "keds" which are so common in the wool of the sheep and which bite the sheep and sometimes suck their blood. They also remove and feed on other bloodsuckers known as ticks.

The starling, you will notice, is a great devourer of insect food, slugs, and worms. In the autumn this is varied with fruit, such as cherries, apples, and pears; in winter they sometimes visit corn yards and attack the stacked corn. On the whole **this bird is a useful one,** and it is interesting to note it is one of the few birds whose numbers appear to be increasing in our land.

Summary.—Let us remember in particular four things about the starling, viz.

its marked parental care, seen in its persistent search for food for its young;
the large amount of food its young require;
its great partiality for insect food;
the remarkable flying feats of the birds when in companies in the autumn.

The teacher should frame other lessons upon similar lines regarding such birds as are common in the school locality. Notes upon a number of common birds will be found in the Author's *Aims and Methods of Nature Study.* References to useful books on birds are given on p. xv. See also Scheme of Study p. 442. Rural teachers should make a special study of the birds, paying some attention to their relations to farm life. Guidance in this direction may be obtained from the Leaflets of the Board of Agriculture and Fisheries dealing with birds. These leaflets may be had free on application to the Secretary of the Board.

LESSON XXXIV.

BIRDS' EGGS.

[Many eggs are not required for the following lesson, although if a collection is available it should of course be made use of. If it is possible to get a few of the particular eggs quoted in the lesson it is desirable to have them; these will be quite sufficient.]

I. **Familiar Birds' Eggs.**—Most of us have seen the eggs of some bird or another within the nest. We might begin this lesson by your writing down the names of the different birds' nests in which you have seen the eggs, especially if you are sure you know the eggs themselves. Perhaps some of you know the eggs of birds very well and your list is too long to write out. If so, write out the names of a dozen eggs you know.

Attractions.—What is that about the eggs of birds which fascinates us all and makes us want to own them? The eggs are usually very attractive to look at. That is one reason. Another is, that we are all mostly fond of collecting, and the possession of a collection of eggs means not only something pleasing to look at and arrange from time to time but gratifies us as evidence of something done—an achievement, viz. the discovery of the nests ourselves, and the ability to recognise them, in which we have at least been as successful as others or more so. The temptation to collect eggs is very strong. The more, however, we get to know the birds themselves, the more careful we become about taking eggs from nests, until we cease to do it at all. And we never take more than one from any single nest. It is more interesting to watch the parents engaged in hatching and rearing their brood, and in watching the young birds themselves.

Special Features.—We have all seen a number of birds' eggs. What is the special feature about them? Most of them are coloured. This is the chief attraction. Let us name a few common birds and the appearance of their eggs. There is the **starling.** What is its egg like? A rather longish egg, narrow and tapering, pale blue, without spots. The **hedge-sparrow's** egg is also blue, although deeper in colour, and so also is the **redstart's.** The **thrush** also has a blue egg, but with a few spots—not many—of a very dark brown colour. Do you know the **blackbird's** egg? It is a rather pale greenish blue, with many light brown specks upon it; sometimes the specks are so numerous that we can scarcely see the ground colour.

Have you seen the **lark's** egg? It is greyish, with light brown specks. The egg of the **chaffinch** is well known. It is greenish blue, with brown spots and streaks. The spots are usually paler around the edge and more reddish. Sometimes the egg is pale blue. The eggs of the **yellowhammer** are interesting. They are pale purplish white, with fine lines and streaks of brown. The **nightingale** has a beautiful egg of a dark olive-brown colour. **Gulls'** eggs are often greenish brown in colour, with brown blotches. Those of the **lapwing** resemble these somewhat. I hope you know the **swallow's** egg? It is white, sprinkled with small brownish or dark red dots. The **martin's** eggs are white, and so also are those of the **swift. Owls'** eggs are also white, and so are a good many others.

The list of course is a very long one, and we must bring it to a close. Let us name just one or two more. What about the **robin's** egg? It is reddish white, faintly speckled with pale red. And we had almost forgotten the **sparrow?** Its egg scarcely needs description—greyish white, with longish spots of pale grey or greyish black.

If you have any or all of these eggs to examine you must do so, and make a set of drawings, coloured as well as you can, to represent some of the most striking.

Why are birds' eggs coloured? * I think that is too difficult a question for you to answer with certainty. Different answers have been given which do not seem complete answers. Whilst we need not attempt to answer the question, we can notice certain simple facts about the colours.

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* The teacher will find the subject discussed under "Eggs" in Newton's *Dictionary of Birds.*

(1) **White eggs.**—Some are without colour, *i.e.* they are white. There is an ordinary fowl's, for example. So also are pigeons' eggs. And owls' also. The kingfisher lays a beautiful glossy pure white egg. The dipper, a charming bird of brown colour with white under parts, which flits about the banks of streams, sometimes running under the water seeking insect larvae, also lays white eggs. We have already noticed the eggs of the martins and of the swift, which are of this class also. It is quite true, as has been pointed out, that a good many of these birds nest in places where the eggs are **hidden from the light,** but there are also cases of white eggs laid in exposed places.

(2) Sometimes the eggs have what is called **protective** colour. They resemble their surroundings, and in this way escape notice. This is often the case even with eggs which look conspicuous when held in the hand, such as the bright blue eggs of the hedge-sparrow. The terns lay their eggs in a hollow in the sand, and these resemble the pebbles on the beach. The eggs of the lapwing are dull coloured, like the earth upon which the nest is laid.

(3) **Family Colour.**—In groups of birds belonging to the same family there is a marked resemblance in the colour of the egg. For the crow family, for example, there is a group colour—raven, crow, rook, jackdaw, hooded crow, all have eggs of a greenish tint speckled or blotched with brown. Another family group is that of the gulls, with eggs of an olive-green tint with brownish black blotching. If you have ever seen the eggs of any of the falcon family—such as kestrel, merlin or sparrow hawk—you would notice that the eggs have a reddish or reddish brown colour upon a pale, almost white, under colour.

(4) **Variations.**—The eggs of each kind of bird usually vary a good deal in colour. Sometimes in a clutch one egg is noticeably different from the rest. One interesting case is that of the guillemots. Their eggs

vary very much in colour, sometimes pale, almost white in colour, cream often, in other cases bluish green, but always with blackish blotches. An interesting contrast to this is the fact that the shape of the egg of this bird is always the same and it is an uncommon shape. It tapers like a top. Shape in this instance is clearly of more importance than colour.

The Shell.—Can you name any other animals besides birds which have shells to their eggs? Reptiles are the only ones amongst the higher animals, *i.e.* snakes, lizards, tortoises, and such like. What is the use of the shell? In the first instance it must be useful in keeping the contents moist and preventing evaporation. Most eggs of animals are laid in water, *e.g.* those of fish and frogs, others in moist earth, such as those of slugs and snails, and these have a tough skin upon the outside, as also have the eggs of insects. Owing to the birds' eggs requiring the heat of the parent's body shells are necessary to protect from risk of damage. And we have seen, too, that in some cases the colour of the shell is used to conceal the egg and so protect it from interference.

Some other questions you might think over and answer are: Why are eggs usually narrower at one end than another? Why are egg-shells porous? Why do hens turn their eggs? What is the weight of an ordinary hen's egg?

II. So far we have dealt with the externals of birds' eggs. But there are some interesting points to note with regard to the contents of an egg. Let us take

AN ORDINARY FOWL'S EGG.

Note its **shape.** Why have eggs in general this particular shape? They lie better together in a nest, less room is taken up by their having a narrow end and a broad.

Observe its **texture.** Eggs vary in smoothness. Note that the eggs of aquatic birds, *e.g.* ducks, have a surface which does not wet readily. Egg-shells are porous, because gases must pass in and out of a living egg—oxygen inward for breathing, and carbon dioxide outward—the waste of living substance. Moisture also slowly passes out from the egg, through the pores.

Membranes.—What lies below the shell? Two membranes. You can see that there are two if you examine the broad end of a hard-boiled egg—one against the shell and one against the white of egg.

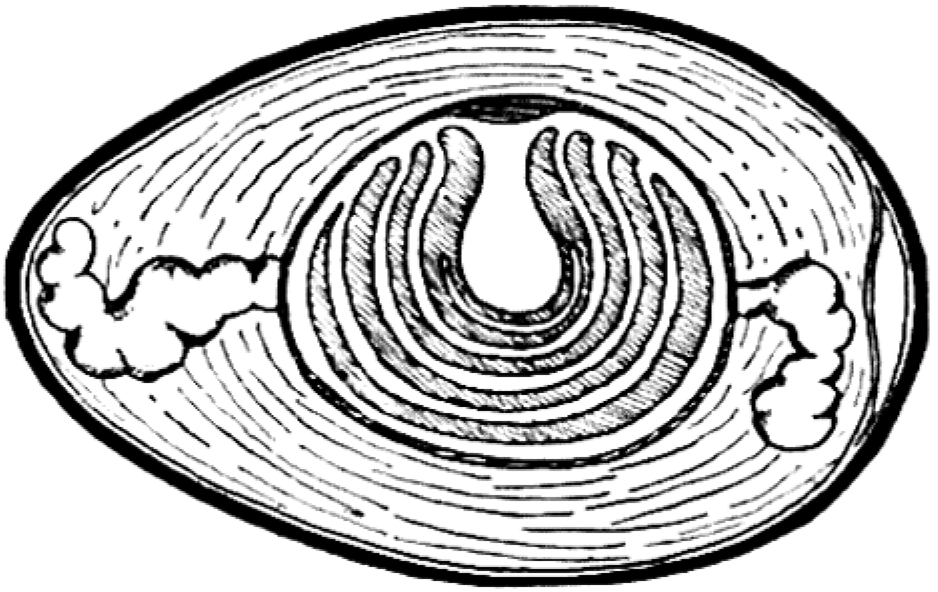

Fig. 76.—Diagram to show the parts of a fowl's egg as seen in longitudinal section. The parts represented are the shell and its membranes, air space, albumen in which may be seen the thickened cords (chalazae), yolk in layers with the position of the germ indicated by the dark patch at the top.

Air Chamber.—What is the space between? An air-chamber. What is the use of it? The young bird gets its first breath of air from it before coming out of the egg.

Uses of Shell and Membranes.—Can you think what is the use of these structures? Partly to protect from outside interference, chiefly to prevent loss of heat from within and to regulate slowly the evaporation outwards.

Albumen.—Examine the contents of a hard-boiled egg. You know that the dense white substance is a clear thin jelly-like fluid in the living egg. This is a highly nutritious substance—albumen—existing in three layers, but these are rather difficult to distinguish. At each end there is a strand or cord of albumen—thicker than the rest.

These are attached to the yolk—they suspend it in the albumen and prevent it moving too rapidly when the egg rolls, and act as buffers for it when the egg is jolted.

Yolk.—This substance is enclosed in a delicate membrane not easily seen. If you wish to prove its existence break a fresh egg into a vessel of water. If the yolk all holds together, prick it with the point of a knife. What happens? The yolk flows out. What does the yolk exist for? Having studied the frog's egg you must be able to answer this question.

The Germ.—Beyond all these things there exists something without which the egg is no egg at all. What is that? Something we have not seen, which with the naked eye we cannot see, viz. the **germ,** the living substance out of which the body of a living bird grows. It lies upon the top of the yolk, and although it is **invisible** at first, if the egg is suitably treated, in a day or two we can on opening the egg see the growing bird.

Draw an egg in section (Fig. 76), showing all the parts in their proper places. Do not omit to mark in a dot to represent the germ, which you must never forget is, although the smallest, the most important part of the egg. It indeed is the **"egg proper,"** the other parts exist only to serve its needs.

LESSON XXXV.

A FRESH WATER EXCURSION.

[For the purpose of this excursion the class should carry one or two pond nets, a few glass jars, and one or two wide-mouthed shallow dishes, such as the porcelain basins used in school laboratories. The pond nets may be improvised from a piece of iron wire bent into the form of a hoop and tied to the end of a walking-stick. Over the hoop a fine-meshed muslin bag may be stitched.

The pupils must make a list of the animals seen and afterwards classify them.]

We wend our way to a small stream about two or three yards wide, not far from the school. This stream flows fairly rapidly over a stony bed for the most part, although in places here and there there are pools where the bottom is deeper and more muddy, and the water nearly stagnant. By the side of the road we are passing along there is a ditch with a gravelly stony bed, overhung by the herbage of the roadway, in which a clear streamlet is flowing. The sun is shining brightly and our attention is drawn to some insects which are running rapidly upon the surface of a portion of the streamlet below which a small dam of stones and turf has been formed. We stop for a moment and endeavour to catch some of them. It is not easy, for they are very nimble. We succeed, however.

This is one of the insect types known generally as **pond skaters**; our particular example here is known as *Velia*. In these pond skaters we have an excellent example of the type of insect which is at home upon the surface film. Watch them for a little. It is not so much because of their lightness that they can run where they do as on account of the way they put their feet down. You may be able to see that they dimple the surface of the water.

Look at *Velia* for a moment before we return it to the water. It has a fine velvety looking skin. Its surface is such that it carries a film of water around it, enclosing a very thin layer of air next the body so that it can go below the water and run there without getting wet. It sometimes runs upon the under side of the film, back downward. These pond skaters are **bugs** (*Hemiptera*). They are of the same order as the "green fly" of our gardens. They have a boring, sucking proboscis, which, in the case of the pond skaters, is used for extracting the juices from the bodies of other insects which fall into the water, either dead or living. They may also suck the juices of vegetation, but they are of a carnivorous type. We return the *Velia* to the water.

Besides the pond skaters, you observe these small beetles skimming and whirling with extraordinary rapidity upon the water. These are **whirligig beetles**, which run upon the surface or swim below with equal ease (see p. 206).

We lift some of the larger stones in the bed of the little stream and find adhering worm-looking creatures, very small, with thickened ends next the stones. They bend and loop their bodies like leeches when we place the stone in a vessel of water, and we can just see a fringe at the free end reminding us of the fringes at the mouth of the larval gnat. These, too, are larvae of a fly—in this instance of a **midge** (*Simulium*), one of those small creatures which sometimes abound in enormous numbers near streams, and which bite us so persistently and annoyingly. Perhaps you did not know that these creatures spent their early days in streams.

Let us look now for the pupae, which are sure to be here. Yes. Look at these brownish scale-like bodies adhering to the under side of this stone. They resemble wet decayed husks of corn. They are open at the top. Some of them we note are empty, but in others we find the pupa with two tufts of very slender whitish threads at the head. I see these with my lens, but you may just manage to see them with the naked eye. Larva and pupa are a little over a quarter of an inch long, but the winged insect is smaller.

Some of you have found, I see, some **caddis-fly larvae.** These grub-like creatures, dragging a tube of sand cumbrously along amongst the gravel, are the larvae of a very common type of insect. Many kinds of tubes are made by them, depending upon the nature of the stream they live in, some of twigs, or blades of grass, or leaves laid down lengthwise around the body, others with short twigs placed crosswise, some of small shells, and there are some which are daring enough to roam freely in the streams without such protections. All the tubes are lined with silky-like threads, and there are some caddis larvae spin snares of these threads with which they catch creatures, often as big as themselves. I have known tadpoles kept in a school aquarium captured in such snares.

The habits of these creatures are very interesting. These may be watched in a school aquarium. As they breathe by gills and live mostly in streams, they require the water well aerated to live healthily. If they are removed from their tubes (do this carefully so as not to damage the creature's body) they soon set about building new ones, and will generally take what material is given them for the purpose. The adult insects have large wings upon which there are fine hairs. The Order is known as *Trichoptera.*

We must, however, hurry on to the larger stream. Arriving there, we set about "fishing" and filling our jars. In quite a short time we have obtained a good and varied collection. Our method is as follows:—With our net we dredge a likely pool, just scraping the bottom, emptying out the contents into one of our tall glass jars into which we have put some clean water from the stream. The pool is evidently a rich one, for already we note an abundance and a variety of living forms. See! we have caught some little fishes. What are these?

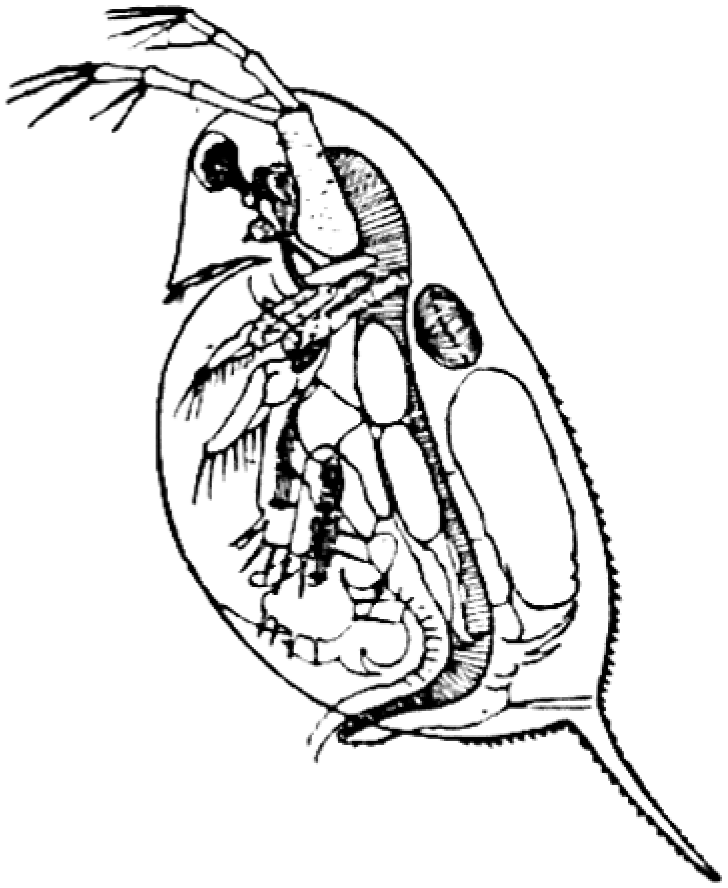

Fig. 77.—*Daphnia*, a common water-flea.

They are young **three-spined sticklebacks** (*Gasterosteus aculeatus*), some only three-quarters of an inch in length. Do you see the quivering movement at the sides of the body? That is produced by the action of the fore (paired) fins. Most fishes progress by the propelling action of the tail fin, but these sticklebacks sometimes use their front paired fins (pectoral fins) for this purpose. We shall pour some of these into a porcelain basin or shallow glass dish so that you may see them clearly.

Notice the very great numbers of **water fleas,** mostly

Daphnia (Fig. 77), swarming near the bottom of the jar. Take a look at these with a lens or hand magnifier and you will see how they propel themselves by a jerking movement of their long feelers. Here, too, are some female *Cyclops* amongst them (Fig. 78), carrying their brood-sacs full of eggs. Although termed fleas, these belong to the group of animals termed Crustacea; they are not insects.

These small very active creatures with the shiny brown and yellow backs, swimming constantly around the jar, are **water beetles,** belonging to the same family as the large water beetle (*Dytiscus*). Their habits are similar although they are so very much smaller, being only about a quarter of an inch long.

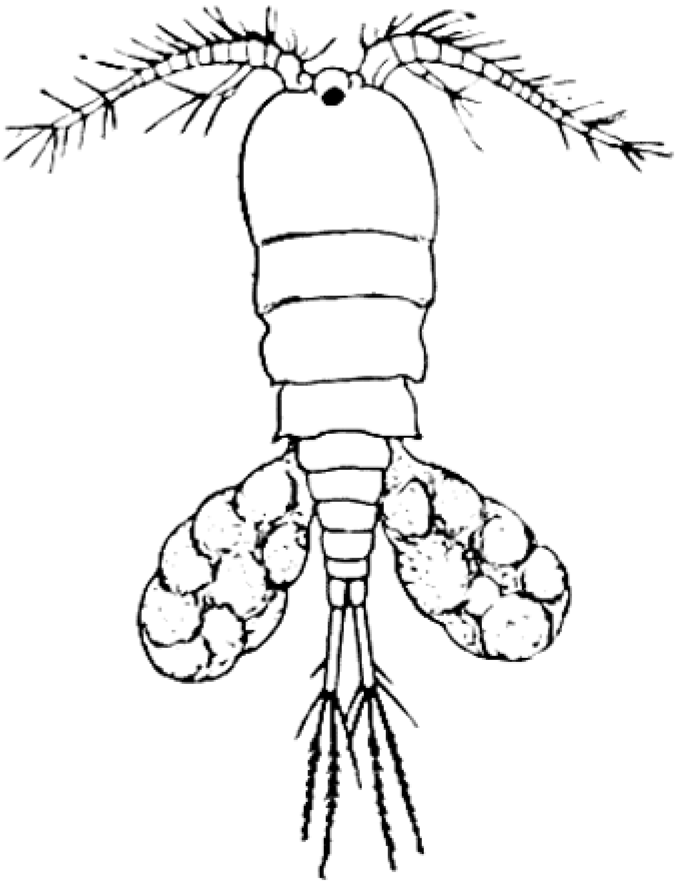
Fig. 78.—*Cyclops*, female with a pair of egg sacs.

Look at these fine swimmers with the curved, flattened bodies and numerous feet. What are these? These are specimens of a well-known Crustacean known as *Gammarus* or the **fresh water shrimp.** The movements of this creature are extremely interesting. Notice how it curves and straightens its body, how it rises and falls, its feet paddling incessantly. Sometimes it swims with feet downward, at another time it sails along at full speed almost upon its back. Is it not splendidly adapted to life in the water? The *Gammarus* is an animal you should always have in your school aquarium. It feeds upon dead or decaying substances, and is thus useful in helping to keep your school jars in a healthy state.

What a world of excitement is this jar of aquatic things! Do you know the familiar *Corixa* or **water-bug** (Fig. 79)? Look at its flattened body with the silvery gleam along its margins, due to the air supply it is carrying, and its long oar-like legs. It also is well adapted to move about with ease and rapidity in the waters of the stream.

Another haul of the same kind has brought up some **larval may-flies** (*Ephemera*), as well as more of what we have already seen. The may-fly larva is interesting to look at; it is a pity it does not live well in the school aquarium. Placing some in our porcelain dish, we are able to see them more clearly. We hold the hand magnifier over the dish. Notice the three long tail filaments, and the quivering gills at the sides of the hind body.

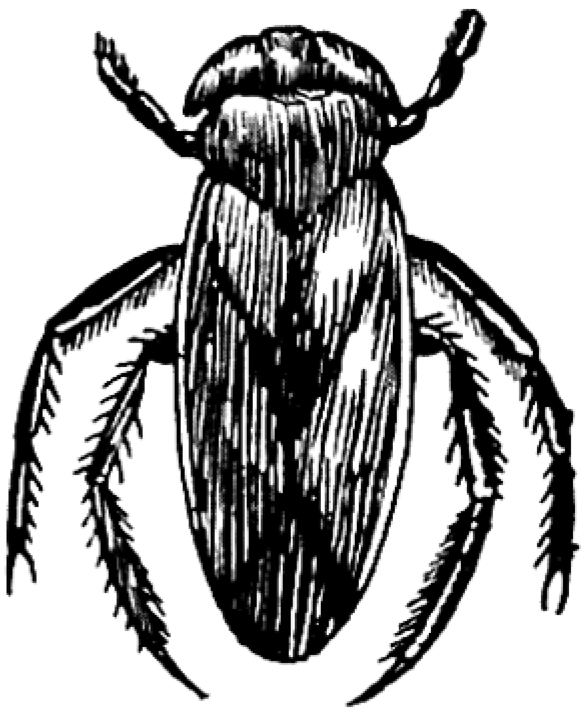

Fig. 79.—*Corixa*, a common water-bug.

These insects, like the caddis larvae, are more completely aquatic than the gnats, for they have organs which enable them during this period of their existence to breathe in the water without the necessity of rising to the surface for air. The may-flies are further interesting because of their remarkable life-history. They spend years in the water feeding and growing. Then they pass through an intermediate (nymphal) stage, eventually becoming winged insects of the air. Their life in the air is very short—a day or two at the most; they do not feed, but simply pair, lay their eggs, and die.

Do you observe these small round animals not much bigger than pin-heads. Notice how rapidly they swim around the jar. They are **water mites.** And these slender, pale, jerking creatures, with movements similar to those of the larval gnat, are the **larvae of flies** of various species. Down at the bottom amongst the sediment, and rising out of it, twisting and jerking in a similar manner, are some of a bright red colour. These are popularly known as **blood worms,** although they are not, of course, worms at all. They are the larvae of insects you very likely know, the **harlequin flies** (Figs. 80-82). These are similar in size and general appearance to gnats, although their habits are different and they are much more common. They dance in companies in the evening air in summer, but do not bite. These larvae may be kept in the school aquarium and the adults hatched out.

Small **brown trout** can be seen in the stream. We capture one after a little difficulty, so that we may admire at closer view its brilliantly gleaming and handsomely spotted scales. Notice also its elegant and shapely form and grace of movement. A fish in its element is always an interesting sight. We capture, by means of our net, also a young and lively **eel.** It is dark in colour, about three and a half inches long, and very slender. It seems quite likely, from its size, that this is its first summer in fresh water (p. 102).

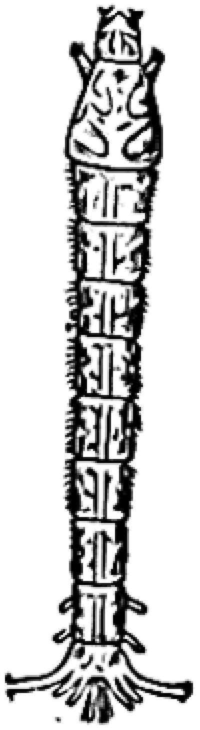

Fig. 80.—Bloodworm Larva of *Chironomus* or Harlequin fly.

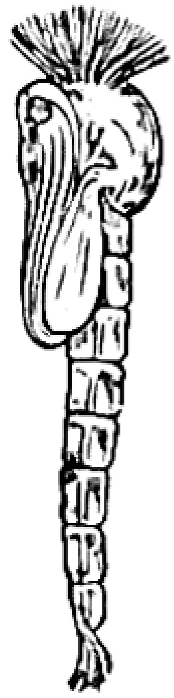

Fig. 81.—Pupa of the Harlequin fly.

Here is another fish, quite different from any we have seen yet. These small and wary little fish are **loach** (*Nemachilus barbatula*). The water is rather deep here, but we manage to secure one. Notice the rather pretty pale markings upon the side of the body, the six barbules about the mouth, and the somewhat broad squarely cut tail fin.

We pass along the banks of the stream to a shallow part in which there are numerous large stones. This is quite a good place for a stream hunt. Let us see what we can find. Reaching out into the stream we pick up a large stone and examine the under side. What are these large, flattened-looking insects which scurry about hurriedly and then lie quiet in a crevice on the stone? These are **stone-fly** larvae. Notice the two long tail filaments. Notice the **pond snails,** with their dark brownish-green shells. We place these in our porcelain dishes in a little water, and soon the snails creep out displaying a pair of large triangular-shaped horns. These snails belong to the genus *Lymnaea.* This short cord of jelly-like substance adhering to the stone is a mass of pond snail spawn. Can you see that it consists of a mass of small transparent eggs?

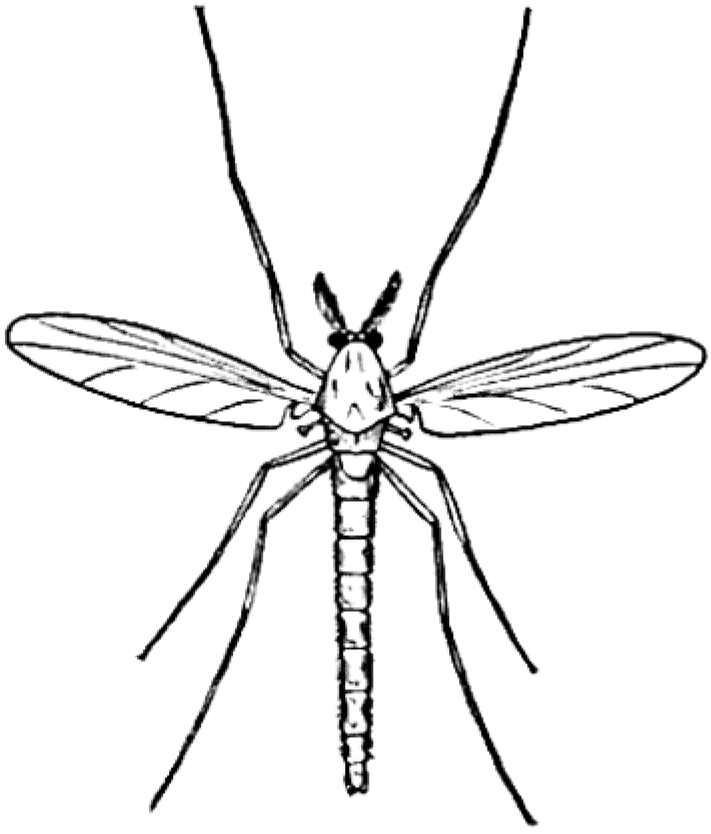

Fig. 82.—Harlequin fly—Male.

Here, upon another stone, are a number of small cap-shaped shells like little helmets. These are specimens of the **fresh water limpet** (*Ancylus fluviatilis*). On many of the stones here we find masses of small stones glued together in little clusters. We open one and find within a long brown, smooth ovoid body with tough shining skin. This is a pupa of a caddis-fly. And here we find fine silk threads to which are matted small stones. This is a snare of one of the caddis-flies already mentioned. On the smoother stones we find small thin blackish creeping creatures like slugs. These are not slugs, but **flat worms** (*Planarians*). We get a good view of them when we allow them to creep in the water in our porcelain dish. These flat worms are very common in streams, and sometimes one gets the common pond weed (*Potamageton natans*) having large numbers creeping on almost every leaf.

The afternoon is now well advanced, and the time has come to bring our visit to the stream to a close. We have not by any means exhausted its content of animal life. But you have seen within a short space how the waters teem abundantly with living things. Each is working out its own life-history—not independently of the others, for life here, as everywhere else, is a maze of inter-relations. We can learn their habits only by degrees. You must therefore watch the creatures in your school aquarium from day to day, noting their feeding, hunting, and other habits, the changes they undergo, and the slow, or it may be sudden, fulfilment of their lives.

Classification of Animals Found at Excursion.

(For place in the animal scale of the undernoted groups see Appendix.)

Turbellaria.—Flatworms, *Planaria.*

Crustacea.—"Fresh-water shrimp," *Gammarus.*
  Water fleas, *Daphnia.*
  Cyclops.

Insecta.—Diptera—
  "Blood worms," larvae of *Chironomus*, Harlequin flies.
  Midge larvae, *Simulium*, Biting midges.
 Coleoptera—
  Water beetles.
  Whirligig beetles, *Gyrinus.*
 Hemiptera—
  Pond skaters, *Velia.*
  Water-bug, *Corixa.*
 Plecoptera—May-flies, *Ephemera** }
 Trichoptera—Caddis-flies * } larval stages.
 Platyptera—Stone-flies * }

Arachnida.—Acarina—Water mites.

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* Those marked thus cannot be satisfactorily kept in an ordinary school aquarium. With care all the others may be. The fishes should be kept apart and fed unless the aquarium is large.

Mollusca.—Gasteropoda—Pond snail, *Lymnaea.*
Freshwater limpet, *Ancylus.*

Pisces.—Teleostei—Eel, *Anguilla vulgaris.*
Trout, *Salmo-fario.*
Loach, *Nemachilus barbatula.*
Stickleback. *Gasterosteus aculeatus.*

LESSON XXXVI.

WHIRLIGIG BEETLES.

[Water beetles are common in streams, ponds, and fresh waters generally. The number of species is considerable, varying in size from less than a quarter of an inch in length to over an inch and a half. They are readily recognised as beetles by their close resemblance to land beetles. All are extremely active swimmers. In some cases only the larvae occur in water, the adults living on land; in others all the stages are passed in the water, or at the water's edge in sand or mud or under stones.

A familiar example is *Gyrinus*, the whirligig beetle. In bright sunshine these may be seen in numbers wheeling about upon the surface of clear standing water or a slow running stream. They swim with rapidity under water also. They are predatory in habit, feeding upon other insects, worms, etc., which they devour by means of strong jaws.]

Observation of the Living Insects.—We have here a number of these interesting insects, dancing with great rapidity at the surface of a small glass jar of water. Let us look at them closely, and for a time enjoy the sight. I think it will be difficult for us to see any order or definiteness in their movements. They appear to us to be dancing in the sunlight from the pure joy of living, as children dance. We shall not hurry this lesson, but for a time simply watch their behaviour. From time to time you notice they leave the surface, darting below, where their movements are equally rapid. Now you notice an interesting thing. Each beetle as it darts below carries at the hinder tip of its body a **clear globule** resembling a drop of mercury. Of course you know what this is. It is a bubble of air. Watch the beetle under water for a time. Presently it returns to the surface and the air bubble is set free.

You can see the rapid movement of their feet as they propel themselves up and down this miniature pool. Sometimes they may be seen floating themselves upward in an interesting way. In this vessel there are fragments of decayed moss and small pieces of woody fibre. The swimming movements of the beetles stir this up from the bottom, and quite commonly they seize hold of these fragments, with the result that they are borne swiftly to the surface. The beetle's hold is then instantly released, and the creature again darts immediately below. Or it may skim the surface for a time, and later dive downward soon to seize another piece of woody débris and on it make another swift passage to the surface. The whole thing is delightful to witness, so suggestive is it of pure fun. The beetle does not rise without effort when quite alone, but when clinging to the mossy fragment, decayed leaf fragment, or rotten twig, it is carried passively and swiftly to the surface.

Look at the bodies of those beetles which have been below the water. Are they wet? No, they are **quite dry.** How is this? To understand this we have to look closely at the surface of the beetle. Let us take one in our hands and look at it with a lens.

Surface of Wing Covers.—First, you notice the very fine polish upon the large wing covers. The little beetle's back gleams in the sunshine with the splendour of finely polished metal. Now you must look closer. If your eyes are sharp, and the light good, and if the beetles will remain still for a second or two, you will notice that the surface which looks so smooth is in reality covered by numerous rows—twenty-two in all—of extremely **small pits** or dots. You can see them very clearly if you examine one of the beetles in your hand with a lens. This kind of surface in contact with water has the same effect upon it as very fine tubes have, it forms a film at the place of contact which is the same as the film at the surface. We do not wonder at the beetles being able to run upon the surface so long as their feet are so placed on it as not to pierce the film. And the surface of the body is such that ordinarily it does not break the water film around it, hence it is not wetted.

Breathing.—Why do beetles **carry down air** when they go below the water? In looking at and thinking of the ways of animals in the pool, we learn how closely bound up with the air are the lives of living things. These beetles carry about with them an air supply, without which they could not live. You know that all beetles have a pair of hard, shell-like curved covers to their wings. Beneath these covers, upon the body, are the openings by which the insects breathe. Before darting under water the *Gyrinus* slightly raises these covers off the back, the space below fills with air, which entangled by the edges of the covers cannot escape, but is carried down captive **like air in a diving bell.** The bubble we see at the insect's tail is the outer part of this air supply. It is used by the insect for breathing below water, and when exhausted is set free at the surface.

Tail.—Try to catch a glimpse of the insect's tail as it runs at the surface of the water. If the sun is shining brightly you will see that it looks whitish. A lens will help you to see that the hind end of the body, which projects beyond the wing covers, carries a great many extremely delicate and short hairs. It is by the help of these hairs that the air bubble is entangled upon the beetle as it dives below the water.

You should now make a **sketch** of the *Gyrinus*. Try to get a look at its feet. For this purpose you might take one in your hand, and turn it over on its back. You will see it has one pair of feet suited for running or climbing out of the pool, and two pairs broad, short, and hairy, with which it swims so well below the water, and runs so swiftly upon the surface.

Smell.—Notice that the beetle emits a peculiar smell as you handle it.

Cover.—If you keep the whirligig beetles in a jar, be sure that there is suitable food for them, and keep the vessel covered. If you do not do this they will come out of the water and fly away.

Young Beetles.—Perhaps you will be fortunate in finding the young whirligig beetles. They are not at all like their parents, but long, narrow, and showing a number of joints. The most interesting thing about them is that they are more completely aquatic than their parents, for they have two rows of long feathery-like gills upon the hinder part of the body. They breathe by these, and never need to leave the water.

Lessons on similar lines should be framed upon others of the more familiar animals present in the school aquarium. Information which can be used in such lessons will be found in the account of a fresh water excursion (p. 197), and also in the notes given in *Aims and Methods of Nature Study,* Chapter IX., The Study of Fresh Water Animals.

LESSON XXXVII.

THE LIFE HISTORY OF THE FROG—Continued.

[The lesson should be taught when the tadpoles in the School collections have reached the appropriate stages.]

STAGE III.

In a previous lesson we took notice of the commencement of the third stage in the tadpole's life, when the gill tufts upon the outside of the neck gave place to other gills hidden within—covered over by the skin behind the head. For the past month or so you have been watching the tadpoles **feeding** and **growing,** leading an **active** life in their little pool. If yours is a mixed aquarium you may have seen something of the risks to which they are exposed, you may have witnessed what is not an uncommon sight, their **capture** by the larva of the water beetle, *Dytiscus*, and seen that formidable enemy suck the life-blood from them through its powerful sickle-shaped jaws. Or you may have witnessed their capture by web-weaving caddis-flies, or seen the wary newts cautiously stalk them till within reach, and then with a sudden snap lay hold with their jaws before the unsuspecting tadpole could make its escape.

Besides these tragic aspects there are other incidents of a pleasanter nature to witness. The tadpole at this stage is extremely active, exploring and experimenting, testing things. Now is the time when you should specially nurse them with **careful feeding.** If they are tried with fish, meat and such like they will take to it readily and grow rapidly, although at this stage they thrive very well on a plant diet, which they can find for themselves if ordinary water weeds are growing in the jars. Strangely enough, they are very fond of the flesh of a dead frog, and attack it greedily. If you put in flesh, food, or bread you must be very careful not to allow it to remain until it decays. Be sure and remove it in time so as to avoid the water becoming impure. If you have plenty of water-weed growing do not change the water, but simply add a little from time to time as it evaporates.

When the tadpoles at this stage have grown large and plump, you must make some change in their surroundings so as to allow them to put their snouts out of the water, which they are beginning to try to do. This, along with the appearing of the hind limbs, marks the coming of the next stage.

STAGE IV.

The tadpoles are now best kept in a **shallow vessel** in which there is some kind of an "island," either of weeds or pebbles, arising by a gentle slope out of the water.

Watch the behaviour of the tadpoles at this stage.

What do you now find them doing? Coming to the surface and sometimes resting for a time, supporting themselves on the sloping bank of the "island" with their snouts out of the water. Why are they doing this? For a long time past there has been slowly growing within the tadpole a pair of **lungs.** Now do you know where lung-breathing animals live? They live upon land usually. Such of them as live in water must **rise to the surface to breathe.** This is what the tadpoles are doing. They have not yet ceased to breathe by their gills, but they are

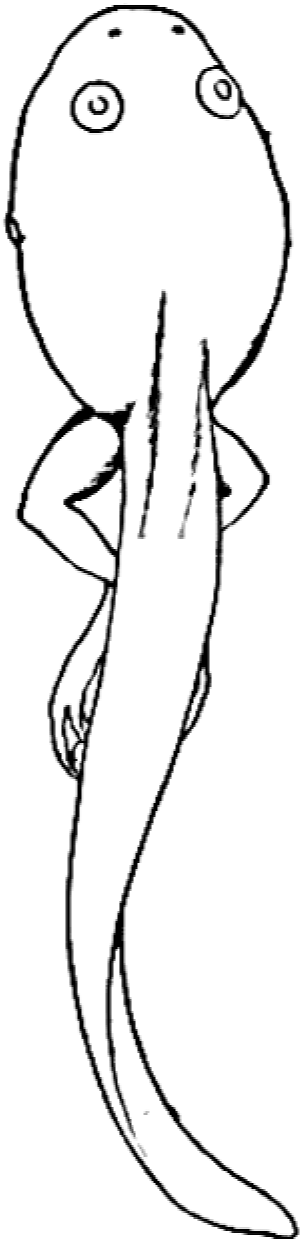

Fig. 83.—Tadpole with hind limbs developed. Note the opening on left side of body through which the water used in breathing passes.

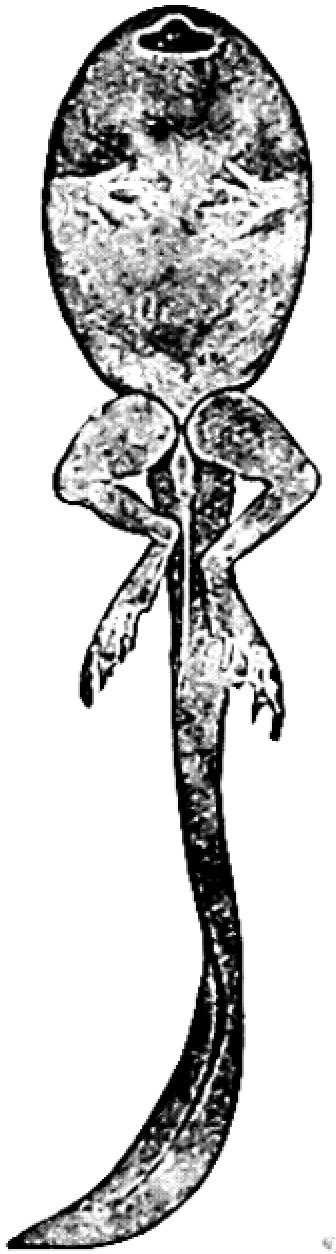

Fig. 84.—Under side of tadpole with fore-limbs visible below the skin.

beginning to use their lungs, and after they do this the lungs grow rapidly. These changes are going on inside and you cannot see them, but in the changing habits of the tadpoles you become aware of them.

The creatures are really preparing for a very important change. What is this change? It is the passage from life in the water to **life upon land.** What other preparations for this change do you observe? The growing of the **hind legs** of course. You must watch their gradual growth. First their appearance as little knobs, then their forming of joints and definite toes. When you can recognise these clearly, count up the **age of the tadpoles** dating from the time that they shook themselves clear of the jelly. Under ordinary conditions they are about **two months** old at this time.

Make a careful **drawing** of the tadpole both before the hind legs appear and after they are clearly formed. In order to do this well, you should have the tadpoles removed to clear water in a small vessel and examine them carefully with a hand magnifier (Fig. 83).

Towards the end of this stage the general **shape of the tadpole alters.** The form is less rounded, and bulgings appear at the fore part of the trunk. Examine the tadpoles on the under side with a magnifier now—what do you see? More or less clearly at the commencement, and as the stage progresses with very great clearness, **the fore limbs are visible beneath the skin** (Fig. 84). You discover that they are growing at the same time as the hind limbs, but they remain under the skin—out of the way as long as the tadpole is unprepared for a life upon land as an air breather. The hind legs come out perhaps because they are too large to pack away after the fashion of the fore limbs.

STAGE V.

You must now closely watch the progress of events. The **fore limbs** appear suddenly, fully formed, on the outside of the body. Examine the tadpoles once more with the lens. What do you see? The left fore limb has pushed its way through the breathing hole which has till now remained open. This opening is sometimes rather difficult to see, but after the fore limb is pushed through, the edges are visible around the top of the arm (Fig. 85). On the other side the limb tears a hole in the skin. You should have no difficulty in seeing the ragged edge of this tear. The shape of the body and head, too, at this time alters and eventually becomes frog-like. Draw the tadpole once more. The tadpole now is an **air breather.**

What familiar creature does it now resemble? A newt. If you remove it from the water how does it move. By leaps like a frog, not crawling like a newt, although in general form and parts it resembles one. There is, however, a real difference that you can see; what is it? The hind legs are long—are those of a frog, suited for leaping, not short like those of a newt.

Stage VI.

During this stage the frog, for it is no longer a tadpole, **fasts.** Externally, the most important change we can see is the gradual **passing away of the tail.** Make a series of drawings to show its gradual disappearance (Fig. 86). By the time it has gone the frog is ready to feed again, and its diet now consists entirely of animal food. It leaves the water and in the wet marshes and fields it now leads an active life, catching insects, feeding abundantly, and growing in size. Every winter the frogs bury themselves in companies in the mud at the bottom of some marsh or stagnant pool. There they fast until the month of March, when the eggs are spawned and again in the pools the life history is commenced, whilst the grown frogs take to the fields and marshes.

When you think over the frog's **whole life history,** and the changes which occur in it, you see that it passes through fish-like stages in which it lives in water, breathing by gills. It is at this time really much more of a fish than anything else. In growing lungs and becoming an air breather it loses its fish-like form as well as habits. But it never quite leaves the water although it ceases to breathe like a fish.

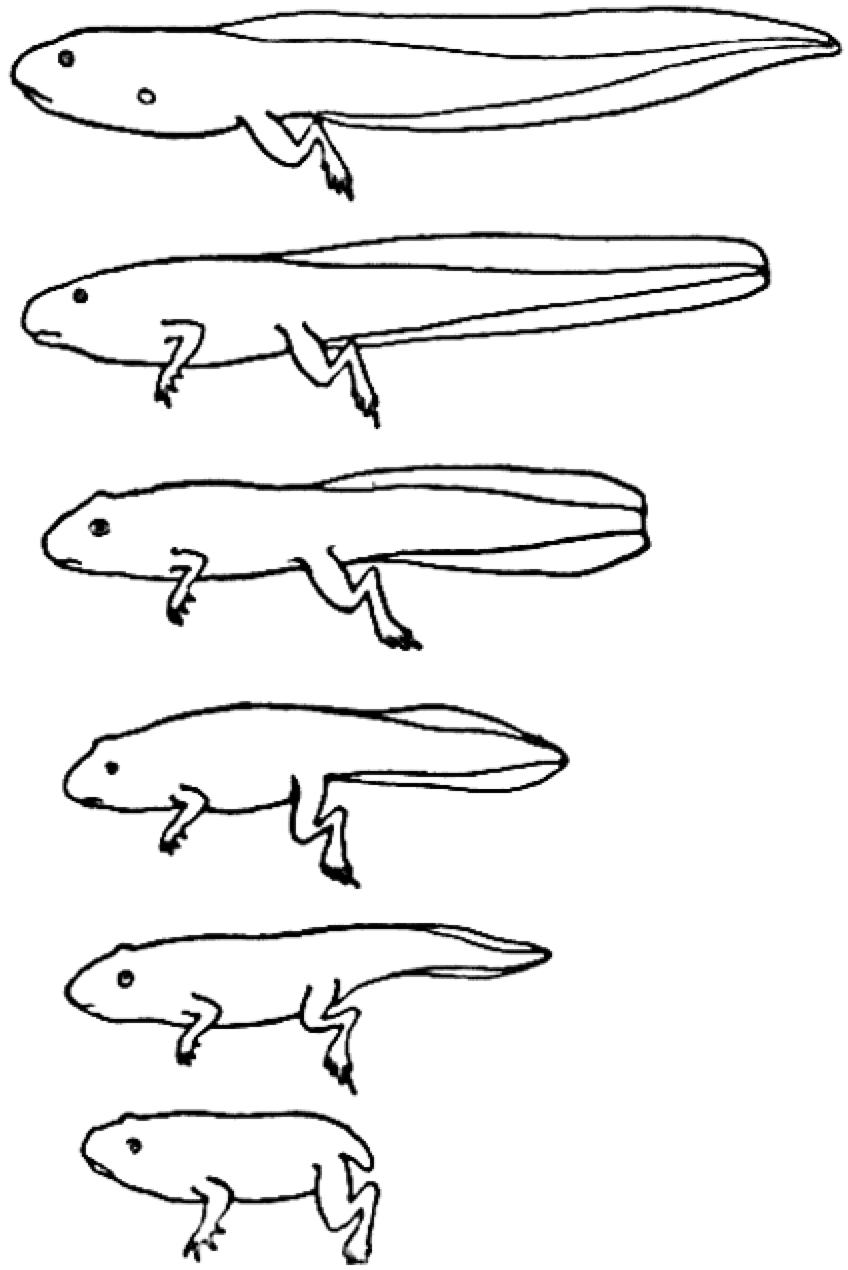

Fig. 86.—Stages in the absorption of the tail of the Tadpole.

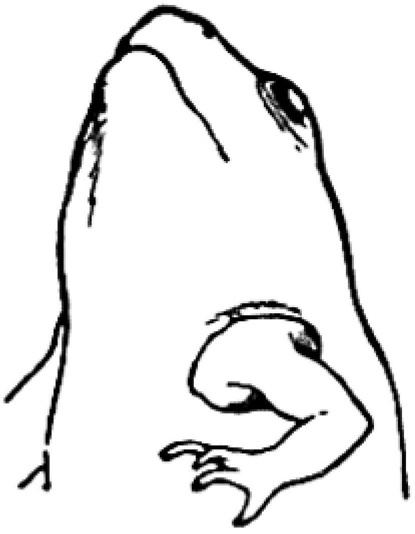

Fig. 85.—Head of Tadpole showing left fore-limb extruded through breathing hole.

Because of its life history and of its habits when grown, living partly in water and partly on land, it is said to be an **Amphibian.** This means a creature which lives two lives. The toad and the newt are also Amphibians. When you are older you will be better able to understand the great interest of this kind of life history, and something of what it teaches us about the past history of frogs and other animals also. Meantime is it not something at which to wonder greatly?

When your tadpoles have completed their growth and have become little frogs, be sure and set them at liberty in a suitable place.

LESSON XXXVIII.

HIVE BEES (*Apis mellifica*).

[The general life of Hive Bees forms an appropriate subject of study. This can be got ideally in an observational hive such as dealers supply. Such, however, is available only to the few, hence we suggest other methods. A suitable starting point is the Worker Bee, seen in the open visiting flowers. With a little skill a Bee may be captured by inverting over it a plain glass tumbler whilst it is busy in a flower, at the same time closing the mouth of the tumbler with a piece of cardboard. The risk of being stung is slight, and the experiment, resulting in no harm to the Bee, is worth the trouble.]

There are many different kinds of bees, a few of which you have all likely seen. We know the humble bee, or bumble bee, in a general way, but of these there are several kinds. The hive bee is the most familiar of the bees.

Several things about bees suggest to us that they are **superior insects.** Can you think in what way hive bees excel most other creatures of the same kind? First, we may notice that they **live in companies** or communities, sharing the work with each other. They are not the only insects which do that. You must name some others. Other bees, *e.g.* the humble bees, many wasps, and ants, and the so-called white ants of other lands, also live in societies like the hive bee, although there are important differences. There are also other insects which may be found in companies, such as the green fly of our gardens, but their life is very different. For although these may all be descended from the same parent they each live **separate lives** as if the others did not exist.

A second very important way in which hive bees are superior is that they **provide for the winter.** They are the only bees which do that. In this connection too they are very skilful in building cells in which to store the honey intended to feed them through the winter, and in which to rear the grubs. But many wasps and other bees make cells, some of wood or leaves and some of wax or wax and pollen. And when we think of other activities of bees, such as the tending of the young, they are equalled and even surpassed by ants and white ants.

The Worker Bee.

In an ordinary hive there are different kinds of bees. Can you tell what these are called? There are the **workers,** of which there is usually a large number. Then there is the **Queen,** of which there is only one fully grown at one time in a hive. Thirdly there are the **drones,** the numbers of which depend upon the season. There are none in the winter. And lastly we must mention of course the **young bees,** amongst which there will be drones, workers and queens.

The worker bee is the one we are most familiar with and we shall commence by looking at it. I hope you have a temporary captive under a glass jar or tumbler. Put a piece of moist sugar beside it, and whilst we wait for it to settle upon the sugar let us examine the bee itself.

Wings.—We shall try to remember the life which a worker bee leads in order that we may notice how well suited it is for the purpose. It is very often called the busy bee, and there is no doubt so it is. When out flying it does not waste time. It is a very rapid flier and yet it has very **narrow wings.** Look at these closely. How many are there? Four, or two pairs. Perhaps the wings are narrow to give more freedom of movement to the legs, which have to do other things besides walk, as we shall see. Also large wings would cover the body too well, and that would interfere with the bee's usefulness when visiting flowers.

But narrow wings are perhaps not so good for flying as broad ones, and the bee makes up for this by having **hooks** upon the hind pair so that they hinge on to the fore pair and beat with them as one. Two broad wings are thus better than four separate narrow ones, that is what it amounts to in the case of the bee, which can fly in a very straight line and very swiftly when it needs to. Have you ever heard of a **bee line**? That means a straight line homeward. That is how the bee flies when it has got all it can carry of pollen or honey.

Hairs.—Look next at the general surface of the body. Is it smooth? No, it is rather hairy. We can see also longer and stiffer hairs upon the legs. Do you see anything adhering to these hairs? If the bee has been visiting flowers you are quite likely to find grains of pollen attached to it. What are the hairs useful for? They are useful for gathering pollen. As the bees bore and clamber in the hearts of flowers seeking honey, they cannot fail to take away pollen upon their heads and bodies, and legs.

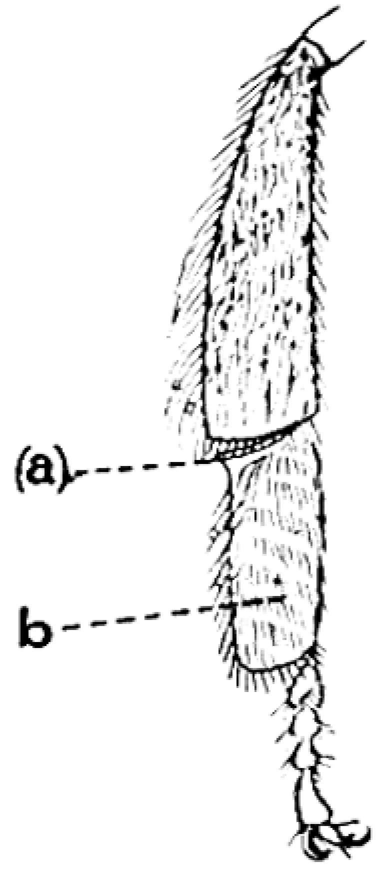

Fig. 87.—Portion of hind limb of Worker Bee.
(*a*) "Wax Pincers."
(*b*) Comb-like hairs upon tarsus for collecting pollen off body.

Hind Legs.—It is worth our while looking at a bee's legs. We shall examine the hind pair. There are a good many parts to the legs of insects, but we need not trouble at present about any except the **two flattened joints** not far from the tip. We really need to hold the bee in our hands and to examine it with a magnifier, but it is worth doing when we get a dead bee.

Look at the drawing (Fig. 87). On the inner side of the smaller of these two flattened joints (*b*) (the one nearer the tip of the limb) you can see a number of close set rows of **stiff hairs.** They are very like the teeth of a comb. These hairs are very useful for combing the pollen from various parts of the body, as are also those on the division above, which is called the **shin.** These comb-like hairs along with the others above form the **pollen basket.**

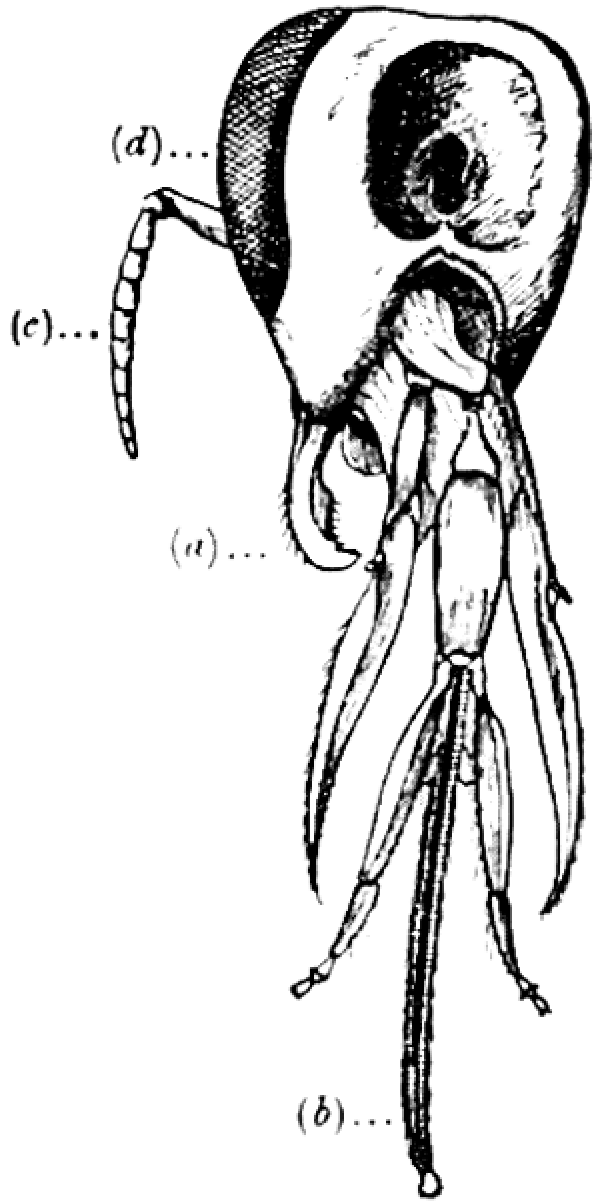

Fig. 88.—Head of Bee. (a) Mandibles used in moulding the cells. (b) "Tongue" used in licking up nectar. (c) Antenna. (d) Compound eye.

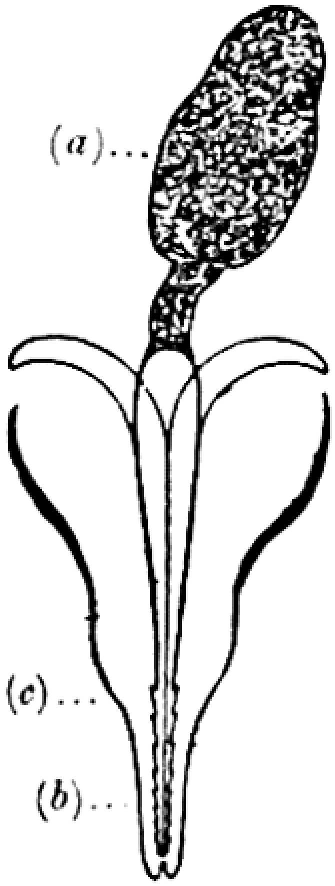

Fig. 89.—Sting of Bee. (a) Poison gland. (b) Sting which is passed into the wound. (c) Sheath of sting, pricking.

The pollen collected by the bee is carried home to the hive in small clumps in these so-called baskets. I am sure you have often seen bees arriving at a hive with their pollen baskets filled.

Wax Pockets.—Look at the under side of the bee's body. You can see lines or grooves running across. In these grooves wax is formed in thin plates, and with this the cells within the hive are made. If you look closely once more at the bee's hind leg you will see a rather **sharp edged slit** between the shin and the division with the comb-like hairs (Fig. 87). This is a kind of pincers, and with it the bee lifts out the wax plates from the grooves upon its body when they are needed for the making of the cells.

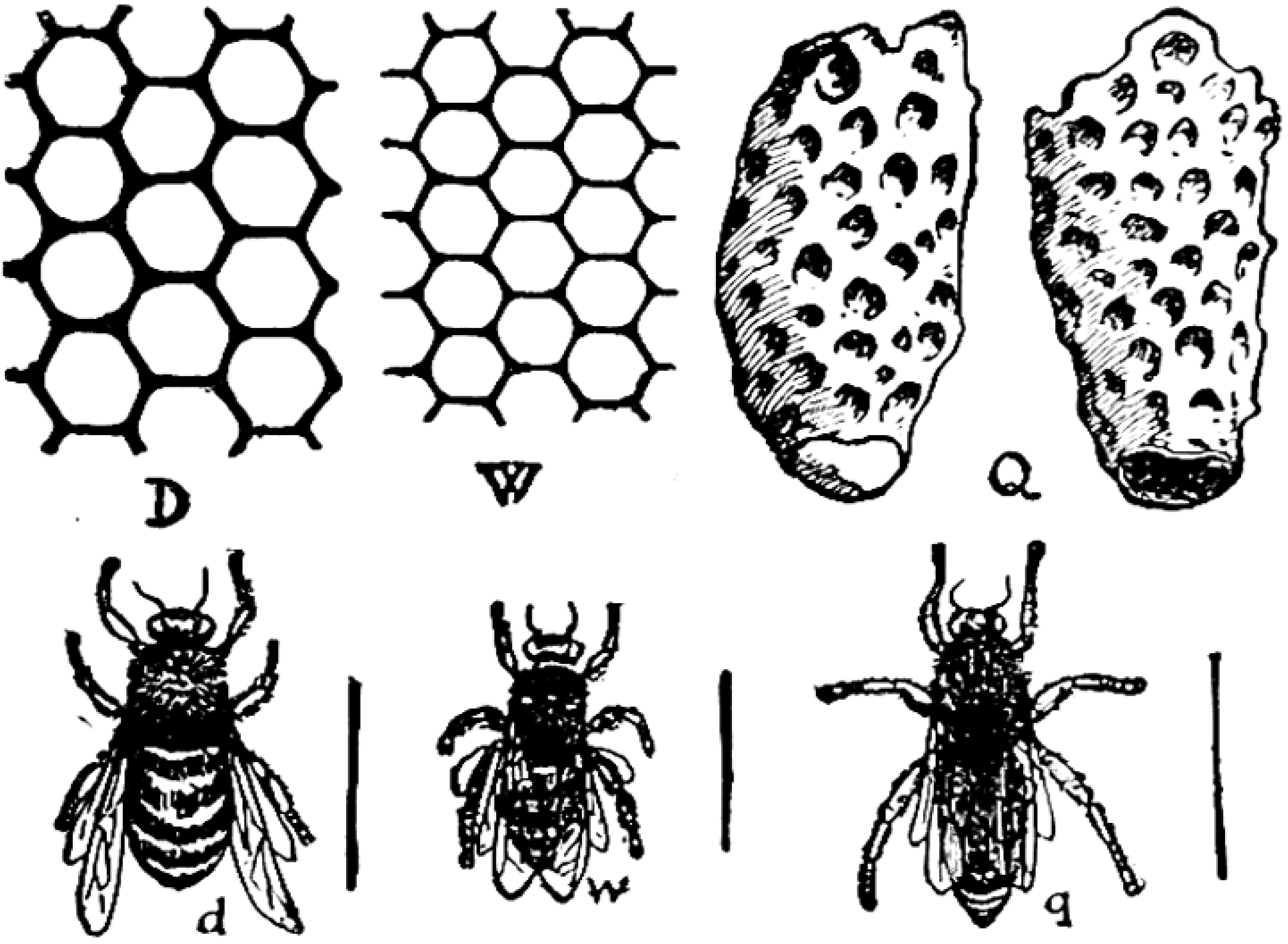

Fig. 90.—Bees and cells. (D) Drone cell, (W) Worker cell, (Q) Queen cells, (d) Drone, (w) Worker, (q) Queen.

Mouth Parts.—The parts of the mouth with which the bee sucks are too difficult for you to understand. But you can easily watch the bee feeding upon the moist sugar. Notice the long centre part which dips up and down constantly. It is fringed with hairs which greatly help to gather the honey (Fig. 88). Besides this there are short strong jaws with which the bee moulds the wax.

Sting.—Perhaps you can see the sheath of the bee's sting. It may be protruding as a little point at the hinder end. It is interesting to know that a bee's sting is the same thing as the sharp rod we sometimes find in other insects which is used for depositing the eggs, sometimes inside the leaves and stems of plants as in the case of gall-flies. Worker bees, although females, do not lay eggs, but use this part for stinging only. The queen has a sting also, but not of course the drones, since the sting is a female organ (Fig. 89).

Can you state what the life of a worker bee consists of? First she serves as a **nurse,** feeding and tending the grubs, and remaining within the hive at this period. Next she shares in the making of cells and goes out to visit the flowers, collecting honey and pollen.

Questions and Answers.—Here are some questions for you to think over:—

1. When a bee first leaves the hive in search of honey how is she able to find it, never having seen flowers before? There are no friendly teachers amongst the bees to show the way. The bee goes alone the first time, and always.

2. When she visits a clover plant, for example, the first time, is she able to find the honey (which you remember is quite out of sight) **in the proper way** by pushing down the keel and wings of the flower and pressing against the standard with her head?

3. As a bee gets older does she become more clever in finding honey, or can she collect pollen as skilfully at the beginning of her days as at the end?

Answers.

1. The bee does not need to be taught, the power to find the flowers is born with the bee. She smells them, then sees them, then settles on them and sucks their nectar or gathers their pollen, just because it is her nature to.

2. Yes. The power to do that is part of her. When creatures can perform difficult actions like this without training or example of others their behaviour is said to be **instinctive.** (Cf. p. 105.) Most of the behaviour of bees

and other insects is instinctive. You will agree that instinctive action may be very wonderful.

3. This will differ with the individual bee. They all do these things *well* to begin with. But some quite likely learn to do them better through practice as time goes on, and to suit their behaviour to circumstances. This improving of behaviour by an animal to suit its need is called **intelligent** action. Notice these two ways of acting. Which do you think is the more wonderful and why?

The facts brought out in the foregoing lesson probably represent the minimum a teacher needs to know in venturing to speak about bees. But if he cares to go further, there are details of the behaviour of the workers both within and outside the hive, and general relations of these to drones and queens upon which observations might be carried out. Intelligent practical beekeepers can be got to explain the meaning of all ordinary procedure likely to be observed and there are several good and even entrancing books to be read. See Maeterlinck: *The Life of the Bee*, and Tickner Edwardes: *The Lore of the Honey Bee.*

LESSON XXXIX.

CATERPILLARS.

[For this lesson the teacher should have some examples of as many different species as can be conveniently obtained. In the early summer those of the magpie moth are all too abundant usually, and these might be obtained. The cabbage butterfly caterpillar may be got during the summer, the tortoiseshell also is frequent upon the nettle: the ghost swift moth at the roots of dock is also readily obtained, whilst that of the tiger moth is common on dandelion, etc. There are numerous other forms obtainable with a little trouble, which, on account of their attractive appearance, are well worth securing, *e.g.* puss moth upon willow (see also the table of butterflies and larvae on page 235). Simple feeding cages (Fig. 91) should be kept in school so that the pupils may see their feeding, moulting, and other habits. For the purpose of the following study it is desirable to have a common

16-legged form, *e.g.* the cabbage butterfly caterpillar (*Pieris brassicae*), and a "looper," *e.g.* of magpie moth (*Abraxas grossulariata*).]

External Appearance.—In this lesson we shall look at the caterpillars in order to see their various parts and to learn the names and uses of these.

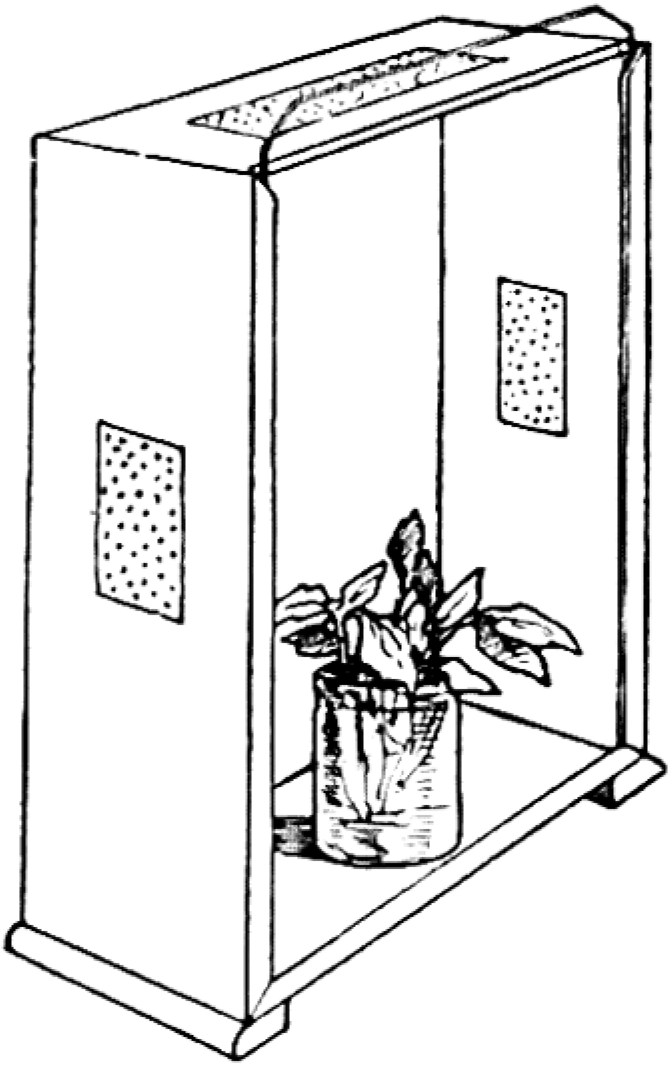

Fig. 91.—Cage for rearing of Insects indoors.

Shape.—First of all, let us notice the shape. All common caterpillars have a worm-like shape. Can you name one noticeable thing in which, besides shape, they agree with worms, and one in which they differ? A worm's body is divided into segments by ring-like grooves, and so is a caterpillar's. But a worm has no legs and a caterpillar has. Count the divisions in the caterpillars. You find you can make out in them all thirteen, including the head as one.

Now you must **draw the body,** showing these thirteen divisions (Fig. 92). Do not make your drawing too small. Next let us examine the **legs**. Are they all of the same kind? No. Behind the head you notice three pairs, then a space, and then more legs, but apparently of a different kind. You must look closely at these. What general difference do you make out between the first group and the second? You can see that the front three pairs are slender and pointed, whilst the ones placed farther back are thicker and more stumpy. In reality, if you examine these front legs with a magnifying glass, you will see that they are five-jointed and have claws (Fig. 93). Fill them in in your drawing, a pair to each of the first three divisions behind the head.

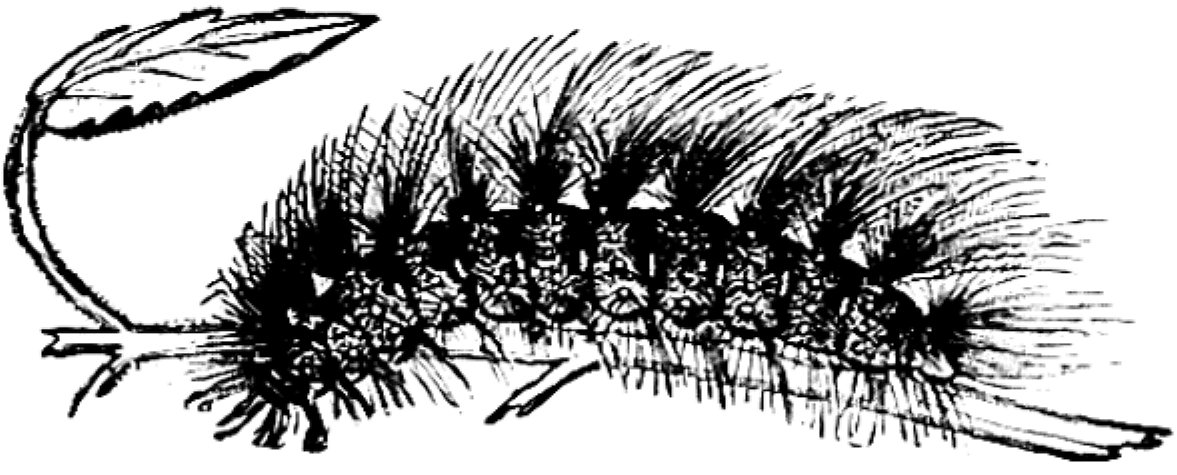

Fig. 92.—The Caterpillar of the Tiger Moth.

It is interesting to notice that these divisions are the parts which carry the wings and legs in the adult insect, and that these legs become transformed into the legs of the fully formed insect. This region, consisting of three divisions, is known as the thorax, and all the part behind it is termed the hind body or abdomen.

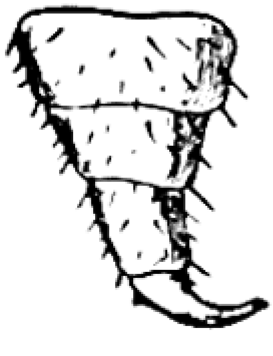

Fig. 93.—Leg of a Caterpillar, magnified.

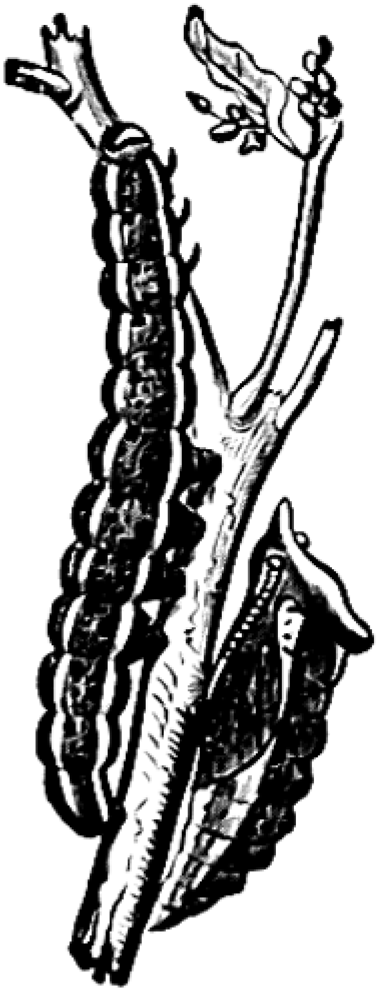

Fig. 94.—Caterpillar and Chrysalis of the Cabbage Butterfly.

Pro-legs.—Now the number and position of the legs upon this last part of the body is different in different kinds of caterpillars. But there are two common kinds which we shall consider. Look at the cabbage butterfly caterpillar (Fig. 94). It has a pair of legs upon each of the seventh, eighth, ninth, and tenth divisions (counting the head as one), and on the last division another pair, making five pairs in all, and bringing the total up to sixteen legs in all. Then if you look at a so-called **looper caterpillar** you see it has only two pairs upon the hind body, one pair on the tenth division and a pair at the end. It has thus only ten pairs of legs (Fig. 95[1]). The number varies still more if we consider other cases, but these may be left alone for the present.

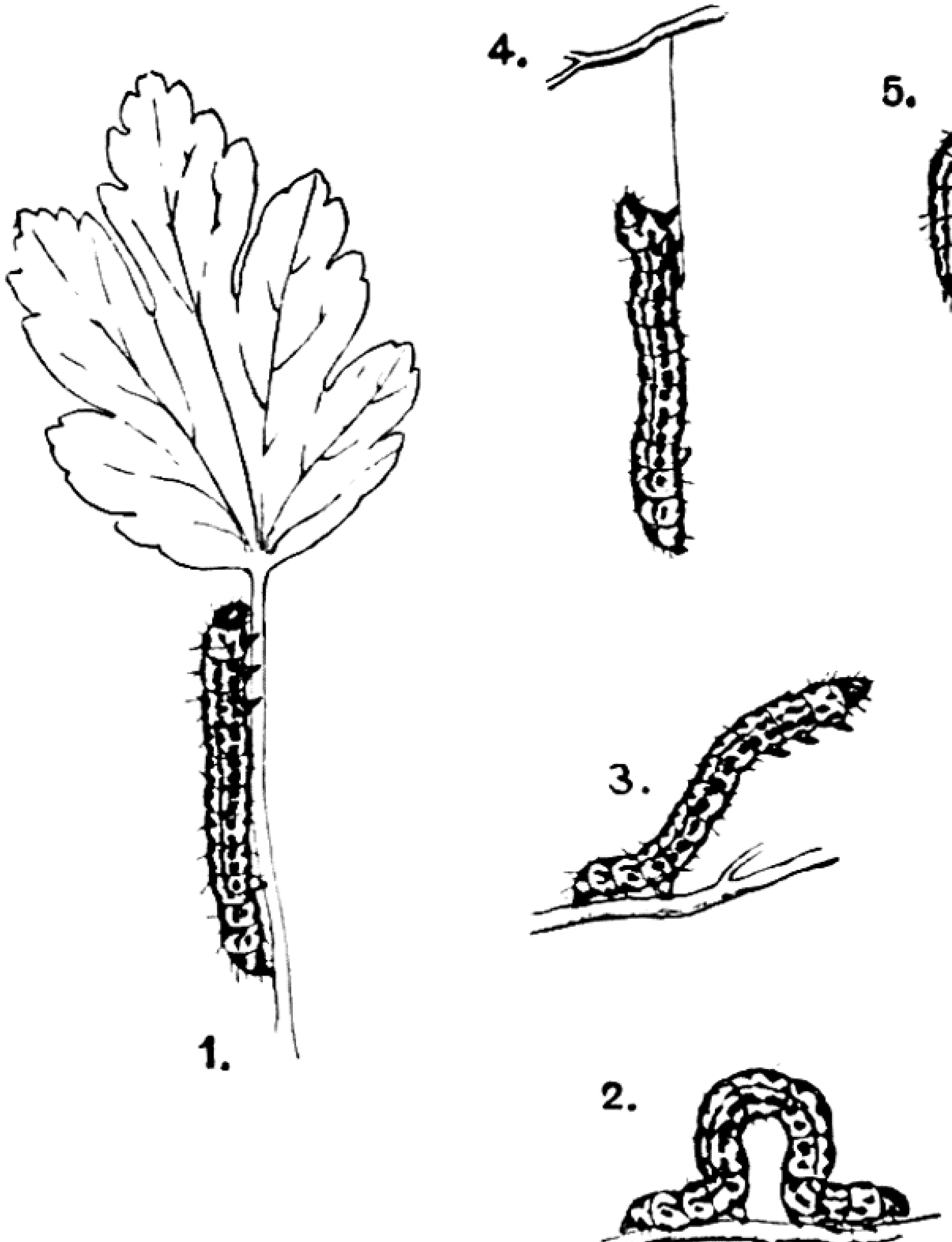

Fig. 95.—The Caterpillar of the Magpie Moth.
The series 1-5 illustrates its characteristic behaviour (see text).

Look carefully at these legs upon the hind body. You will be able to see that they are fleshy or stumpy—thicker than the leg of the thorax, and have rows or circles of very tiny hooks. They are called **pro-legs** (Fig. 96). The last pair is placed so that they clasp or cling to objects, and are sometimes called claspers instead of legs. These pro-legs are so called because they are temporary, and do not occur upon the fully-formed insect.

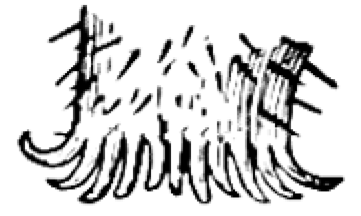

Fig. 96.—Pro-leg of a Caterpillar.

Do you wonder why a caterpillar has pro-legs? The caterpillar, as you are well aware, is a very hungry creature. It swallows large quantities of solid food in the shape of leaf fragments, from which it extracts fluid nourishment. Its body is thus heavy, and would drag heavily on the ground, the creature's progress would be slow, and it could not thus get food sufficiently rapidly. And so it has a number of temporary legs upon its hind body to enable it to move easily and quickly so long as it is a caterpillar.

Movements.—Watch the caterpillar's crawling. You can see a kind of contractile wave passing along the body of the 16-legged kinds as the feet are rapidly moved forward. The 10-legged forms move in a very interesting fashion. Notice how they loop up their bodies. You should make a series of outline sketches, first the caterpillar fully outstretched, then the looped caterpillar. Notice here how the first pair of pro-legs is brought up close behind the last pair of true legs. After the looped caterpillar make a sketch of the insect rearing itself as it holds on by its pro-legs, preparatory to taking a fresh hold by the front of the body. You will understand, after watching the creature moving, why it is called a "looper," and also why this family is termed "Geometers," *i.e.* "earth measurers." (Fig. 95.)

Breathing.—Along the sides of the body of a caterpillar can be seen small oval areas, generally lighter in colour than the surrounding parts. These areas have a narrow slit leading into long highly-branched tubes, which spread into the remotest corners of the body. They are air tubes or breathing tubes. All land insects breathe in this way, through openings on the sides of their bodies.

Parts of Head.—Look at the head of the caterpillar. On it you may manage to see a cluster of **simple eyes**—little shiny dark dots—on each side. There is a pair of short **feelers** also, and in front of the mouth are the **jaws,** which work such havoc amongst plants. Behind the mouth is a minute opening, too small for you to see, but out of which comes the silk which caterpillars spin in their **silk glands.**

Protective Behaviour.—Have you ever, in collecting caterpillars such as the magpie moth, found that as you are about to lay hold of them they disappear? This is not an uncommon thing for them to do. Where have they gone?

As you move or shake the twig on which they are lying they let go and fall. But in doing so they have spun out a fine thread of silk, fixing it to the twig or leaf, so that they do not really fall to the ground. You, by and by, discover that they are suspended in mid air by this thread, and that if you leave them they commence to crawl up again. You can get the caterpillars to do this by letting them fall from a pencil point, and sometimes they spin very long threads. Watch the creature making its return journey. With body stiffened out behind, and head thrown back and then forward to grip the silken cord by the jaws, the acrobat at length reaches the shelter of its leaf. See Fig. 95^4.

What is the value of this habit of the caterpillar? There is no doubt that caterpillars which are able to do this, in a large number of cases will **escape capture** by their bird enemies.

Sometimes the caterpillar falls to the ground. What happens? Hold one in the hand and cause it to fall on the table. It doubles itself, head close to tail, but with the last segment projecting, and **lies motionless** (Fig. 95^5). This is a quite definite piece of behaviour.* The caterpillar has learned somehow the advantage of keeping still; that movement attracts attention, and that to be seen may mean death. Many animals have discovered the **life-saving value of keeping still** in time of danger. In a short time the caterpillar, if undisturbed, slowly turns over and crawls away. You must make drawings of the caterpillar suspended by the thread, and lying passive on the ground (Fig. 95)

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* It will be found that caterpillars after frequent handling or experimenting may cease to act automatically in this way. They appear to adapt themselves readily. But the "fresh" caterpillar always acts in the way stated.

Other Protective Arrangements.—Notice how caterpillars are protected in other ways. You will readily understand how creatures like these, with fat juicy bodies, are quickly seized by birds. You have just noticed how the magpie moth caterpillar protects itself. Nature has given it still another advantage. It is very distasteful to most birds, so that if it is but once tasted by a bird that bird afterwards leaves all others of the same species alone. Thus **an individual is sacrificed for the race.**

Some caterpillars are protected by their colours or by the markings upon their bodies resembling the leaves on which they feed. Others by their markings, and by taking up stiffened positions on their food plant, resemble the twigs amongst which they live. You must keep a look out for examples of these upon bushes and trees throughout the summer.

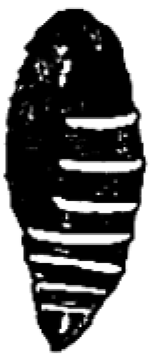

Fig. 97.—Pupa of Magpie Moth.

Moulting.—You must watch the feeding and gradual growth of the caterpillars in the rearing cages in school. What happens to a growing caterpillar from time to time? It moults, *i.e.* throws off the outermost covering of its body (cuticle), having first grown a looser and larger one below.

Pupation.—When a caterpillar is fully grown, at its last moult it becomes a pupa or chrysalis. You must be on the look out for this change. If you are rearing magpie moths it will take place in the end of May or early in June. You must write down what you see. This caterpillar in changing to the pupa is yellowish and soft at first, but soon changes to a pretty, glossy, black and gold banded colour (Figs. 97, 98).

We shall not meantime study the pupae of insects (p. 414). For the present let us try to see the significance of the caterpillar stage in the insect's life-history.

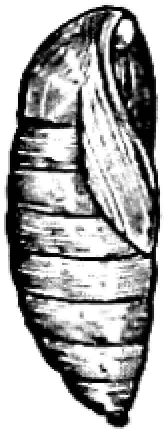

Fig. 98.—The Pupa of the Tiger Moth.

You have noticed, have you not, that the life of a caterpillar is given over entirely to feeding, with growth as a result. We have noted, too, that as a result of growth caterpillars moult. This is because the outer layer of their skins does not grow and must be thrown off from time to time.

Caterpillars you see, then, are but a stage in a life history. When young animals which feed themselves are unlike their parents in general habits and structure they are usually termed **larvae.** Caterpillars are the larvae of moths and butterflies.

Their life consists in feeding and growing.

Collect as many different kinds of caterpillars as you come across during the summer. Note the kind of plant you find them on, and feed them on this in your school "cages." Endeavour to hatch out the adults.

LESSON XL.

BUTTERFLIES AND MOTHS.

[Lessons should be taught on the occasion of the hatching out of pupae in the school insect boxes. It is desirable that various forms should be reared, so that the pupils may have an opportunity of seeing close at hand the variety of colour which these forms of life exhibit. A lesson should commence with an examination and general appreciation of the appearance of the insect. This should be accompanied by a drawing and written description of its general form. Several lessons will be possible depending on the number of different kinds of insects which are available.

As living insects are under examination, notes may be made upon their flight and attitude at rest, resemblance to natural surroundings, and such-like points. The relations of particular forms to particular plants, if known, should also be noted as well as the general significance of this phase in the life-history of the Lepidoptera be inquired into. This can most effectively be done by contrasting the adult in structure, feeding, and other habits with the larva.

By way of illustration a lesson upon an ordinary white or cabbage butterfly is here given. This is a form familiar both in town and country. It may be conveniently hatched out from chrysalids collected in the winter.]

THE CABBAGE BUTTERFLY (*Pieris brassicae*).

General Appearance.—If I ask what butterfly you have seen oftenest, I think you will answer this one, commonly called the large white or cabbage butterfly. Let us look at some examples. These have hatched out from chrysalids which were collected in the winter, some from under beams in outhouses, others from stone walls, window ledges, and such-like places. This butterfly is called the white butterfly because there is a good deal of a whitish colour about it. Notice it is not quite white, but very faintly **yellowish.** What other colour is present? Black. Where do we see the black colour? On the body and feelers, on the tips and along the front edges of the fore wings. On the wings the black may not be quite so dark as on the body, but of a greyish tint (Fig. 99).

If you have a number of butterflies of this kind you will find that they are **not all alike.** What differences do you notice? Some have a pair of black spots on the upper side of each fore wing as well as a dash of black on the hinder border. There is also a black spot on the front margin of the hind wing. The others are without spots on the upper side. What do these differences mean? They distinguish the two sexes. The spotted ones are females.

When the butterflies are resting we see the under sides of their wings and bodies. Is there the same difference to be noted here? We see that on this side both forms are spotted, although in the male the spots are smaller. What is the colour of the under side? The lower or hind wings are of a dull creamy yellow dotted with grey. This colour is also present at the tips of the fore wings. The body is also lighter on the under side.

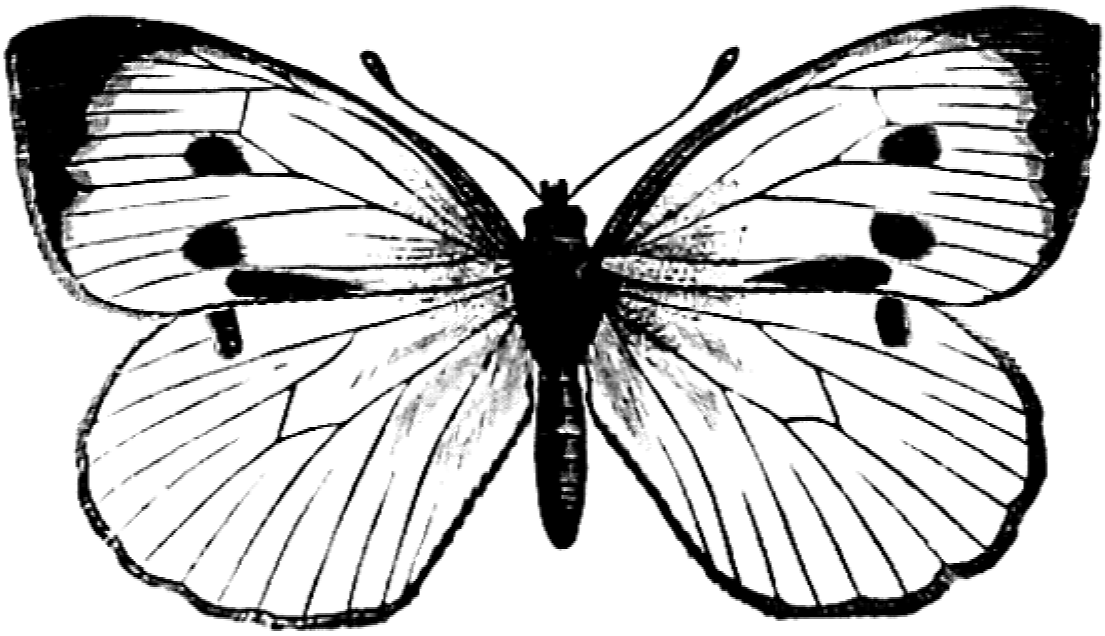
Fig. 99.—The Cabbage Butterfly—Female, natural size.

Now you must **draw the butterfly.** If you look carefully at the insect resting, noting the way the wings are placed, and their shape, you will find this an interesting and easy exercise. **Practise** making a butterfly in outline until you can **draw one from memory.**

Parts of Body.—Before we leave this part of the lesson we must be sure we know all the important parts of the insect's body. We have already noticed that a butterfly has **two pairs of wings.** Their size is of some importance, as there are other butterflies which are rather similar in appearance but not of the same size. Can you judge the distance from one wing tip to the other? About 2½ inches. In the butterfly known as the small white

(*Pieris rapae*) this distance is 2 inches. Then we have also observed the feelers or **antennae.** What do you notice about them? They are **thickened** at the tip. This is a distinguishing feature about our butterflies. The feelers of our moths do not have thickened tips (Figs. 100, 101).

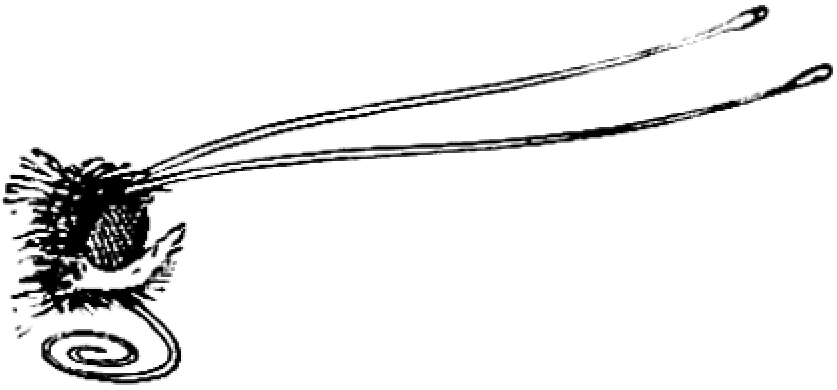

Fig. 100.—Head of a Butterfly, with Proboscis partly uncoiled.
Note the antennae with thickened tips.

Look now at the body. You can see the three divisions—**head, thorax, and hind body.** On the thorax are the **three pairs of legs** upon which the insect walks or rests, and on the head you can see the large **compound eyes,** and on the under side the **long tube** coiled like a spring in front of the mouth.

When we handle a butterfly we discover that parts of its surface are very readily removed. In this case what do you find? When we touch this insect, even lightly, a fine powdery dust comes away upon our fingers. This dust really consists of very small and **fine scales.** If you could look at these scales under a microscope you would see that they are of various shapes and sizes

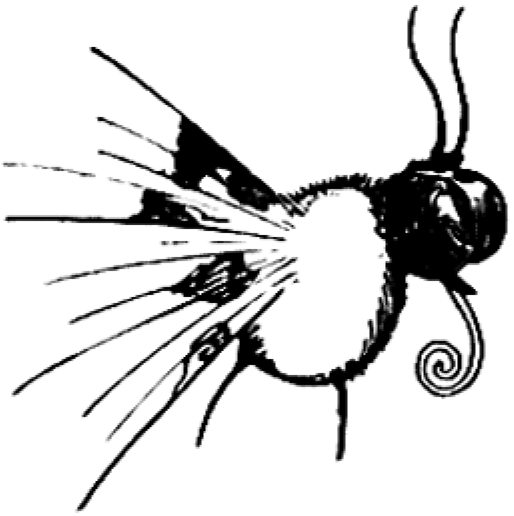

Fig. 101.—Head and Thorax of Magpie Moth. Note the antennae without thickening at tip.

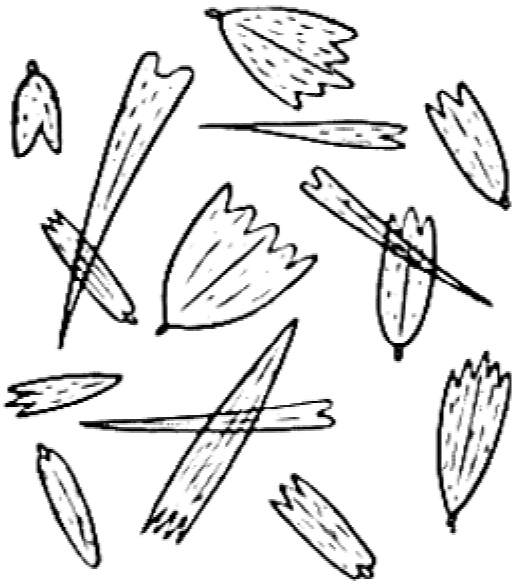

Fig. 102.—Scales from the wing of the Cabbage Butterfly, magnified.

and beautifully formed. These insects are called **"Lepidoptera,"** which means in Greek **"scaly winged"** (Fig. 102).

I hope you will be able to see the butterfly as soon as it comes out of its chrysalis (Fig. 103). Its wings are small at first, and at this stage the insect cannot fly, but it runs very well. It is very interesting to watch the wings expand. They do it very quickly.

Flight.—Now we must watch the butterfly **on the wing.** Does it fly fast? Yes, butterflies are active fliers. How do you describe its course? Straight or uneven? Can you think of the value to the insect of the **irregular course** it usually follows? Will this manner of flying make it easier for the butterfly to dodge its pursuers? What creatures chase butterflies?

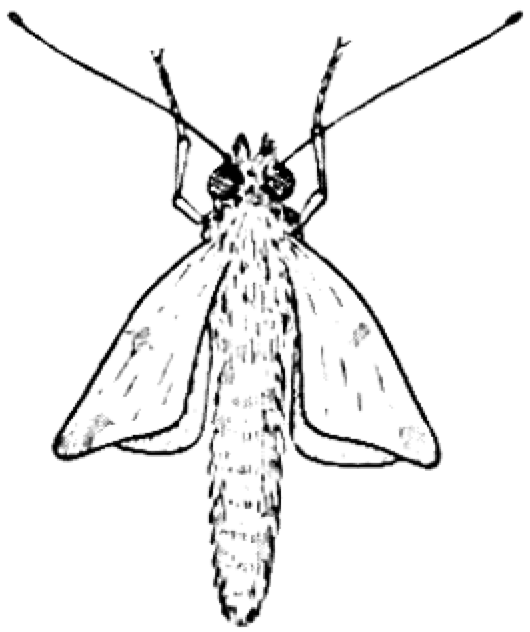

Fig. 103.—The Cabbage Butterfly as it emerges from the chrysalis case.

Butterflies are creatures of the sunshine, they fly in a seemingly aimless fashion, and when they alight upon a flower they rarely remain very long. These things have led many people to think and to write of butterflies as triflers and idlers. But they come out in the sunshine because the flowers which they must visit are open then and wet or damp weather would spoil their wings, they fly unevenly because it is safer, and they stay only a short time upon flowers, because they are very skilful and can feed very quickly, or as quickly deposit eggs.

What are butterflies doing when they fly about?

They are really **very busy.** The females fly from place to place, **depositing their eggs** upon plants suitable for the caterpillars to feed upon. They also stop to feed by the way. To understand the life of a butterfly you should compare it with the caterpillar from which it arose.

Butterfly and Caterpillar compared.—The caterpillar is a creeping thing which finds itself placed upon its food plant. It does not need to travel far. It has no wings. The butterfly requires to travel longer distances in a short period of time. The wings enable it to do this. The food of the caterpillar is solid and heavy—the caterpillar eats a lot because it is a growing creature. The food of the butterfly is **liquid food**—nectar. What is the advantage of this? The butterfly does not grow, nectar is lighter to carry and nourishes rapidly. It is **more suitable food for a flying creature,** in which a light body is an advantage.

The caterpillar has strong biting jaws for cutting the leaves upon which it feeds. We have seen how very different are the chief parts of the butterfly's mouth—a long coiled sucking tube. You now easily understand the meaning of this change. This tube is very skilfully inserted into flowers in which nectar is concealed. It is suited by its length to sucking nectar from deep flowers. How long do you think the proboscis of the white butterfly is? About $\frac{2}{3}$ of an inch. A tube of this length needs to be coiled up out of the way, but the butterfly can straighten it out quite easily and dip it into the flowers whenever it requires to (Fig. 100).

Notice another difference. The stump legs or legs upon the hind body of the caterpillar have disappeared. You understand now how from the different life the butterfly leads that they are no longer required. On the other hand the other legs—true legs—are very much longer. This change is also an advantage to the butterfly both when sucking nectar or depositing eggs, as a better hold of the plant is got with the longer limbs.

Then the colour is quite different in the two cases. We do not always understand the meaning of the colours in insects, but very often there is a general resemblance in caterpillars to their surroundings, and the same in butterflies and moths. Further, the food, as we have just noted, is very different in the two cases. These things we are sure have something to do with the difference in colour. It is interesting to remember that in general both flowers and butterflies are brightly coloured, and that the butterflies' bodies are built up from the substances removed from plants by caterpillars.

Some other differences are the greatly superior antennae in the butterflies, and also the large compound eyes in place of the small simple eyes of the caterpillar. You should try to think how these changes are suited to the new life of the adult insect.

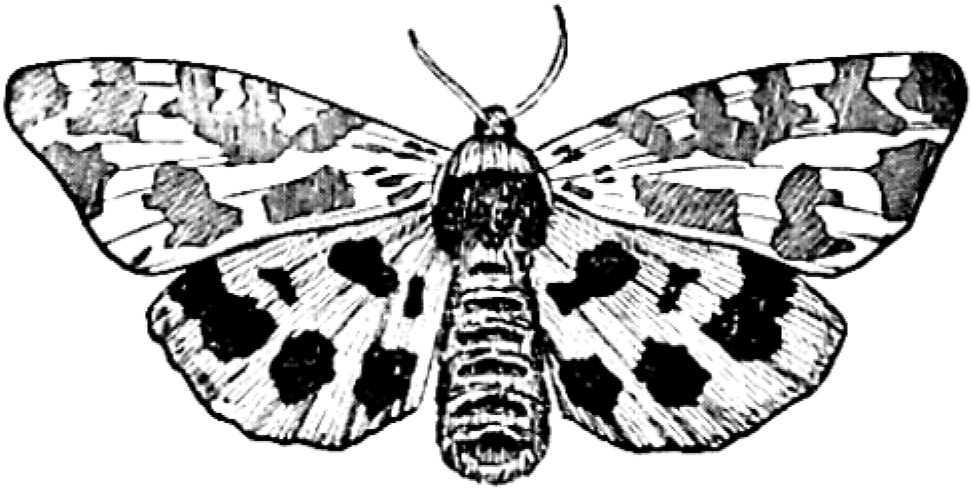

Fig. 104.—The Tiger Moth (*Arctia caja*).

At what time of the year do we see the large white butterfly? In May and June, and again in August. There are thus two broods in a year, a spring and an autumn. In what stage does it pass the winter? In the chrysalis stage. On what does the larva feed? The leaves of the **cabbage,** other Cruciferae, and **garden nasturtium** (*Tropaeolum*).

What flowers does this butterfly visit for nectar? A very large number of different kinds. Some of those it has been seen to be useful in cross-pollinating are the **dog violet,** the **wild pansy, lucerne, ground ivy,** and a number of others.

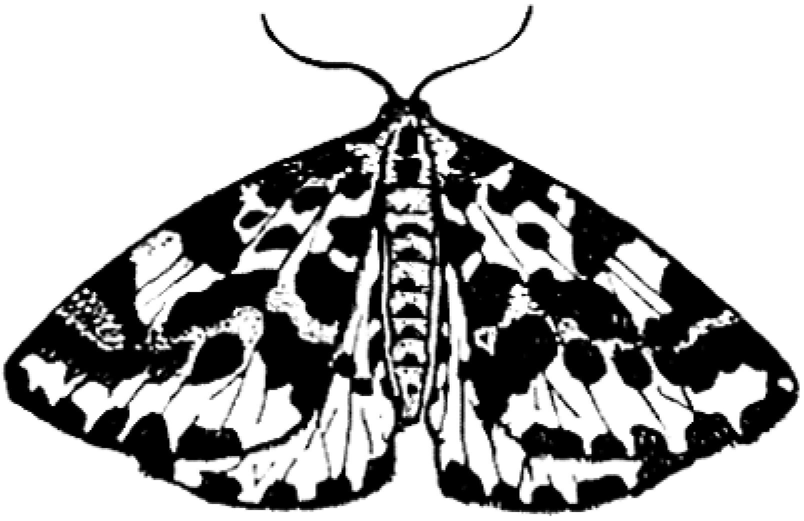

Fig. 105.—The Magpie Moth (*Abraxas Grossulariata*).

You should try to become familiar with the appearance of at least a dozen common butterflies and half a dozen moths. It will be useful for you to record in your nature calendar the times of first appearing of some of these year by year (Figs. 104, 105).

The following information may be of some assistance to the teacher in finding the insects for the above and preceding lesson.

A FEW COMMON BUTTERFLIES AND THEIR LARVAE.

Butterfly.	**When Abroad.**	**Larva, where it may be found.***
Green Veined White (*Pieris napi*)	From middle of April to June, and again from middle of July to Aug. Common	Green, stigmata red in a yellow spot. On turnip leaves and other Cruciferae. June and September.
Orange Tip (*Anthocharis cardamines*)	End of April to end of May. Common	Green, with a pale stripe laterally. On narrow-leaved bitter-cress and other Cruciferae in July.
Meadow Brown (*Hipparchia janira*)	End of June to end of August. Abundant	Pale green, with white stripe laterally. On smooth-stalked meadow grass and other grasses. May.
Painted Lady (*Cynthia cardui*)	March to May, July to Sept. Generally distributed	Brown, with two dorsal and two lateral lines; spiny. On thistles. June and July.
Red Admiral (*Vanessa atalanta*)	August to beginning of October	Yellowish grey, with pale lateral line, head and legs black—prolegs reddish; spiny. Common on nettles. June and July.
Peacock (*V. Io*)	March to May, Aug. and Sept.	Black, with white dots; spiny. On nettles. Common in England; scarce in Scotland. June and July.
Small Tortoiseshell (*V. urticae*)	March to May, June to Sept.	Yellowish grey, with black dorsal line and broad brownish lateral stripe, with yellow line below; spiny. Beginning June to end of August. Common everywhere.

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* Data compiled from Stainton's *Manual of British Butterflies and Moths.*

Butterfly.	When Abroad.	Larva, where it may be found.*
Small Copper (*Chrysophanus phloeas*)	End of May to beginning of Oct. Common	Green, with red dorsal and lateral stripes. May, July, September. On dock.
Common Blue (*Polyommatus alexis*)	End of May to beginning of July, end of July to end of September	Green, with darker dorsal line and a row of white spots on each side above the feet. April and August. On clover and bird's-foot trefoil.

Further assistance in the framing of lessons upon insects and information regarding them will be found in *Aims and Methods of Nature Study*, Ch. XII., "Some suggestions for the study of Insects."

ZOOLOGICAL CHARACTERS AND CLASSIFICATION

of Animals dealt with in the foregoing Chapter.

Insecta.

The insects dealt with in this chapter have been classified in the lessons, p. 205, or are referred to in other parts of the book. For hive bee see p. 421, caterpillars, butterflies, and moths, p. 421.

Aves.

The **starling,** *Sturnus vulgaris*, is a member of the Family *Sturnidae*, Order *Passeres*. Structurally the starling resembles the crows. In its habit of walking, instead of hopping like most other perching birds, we observe another similarity. It differs from them in having at first streaked plumage in the young. The rose-coloured pastor, *Pastor roseus*, is another member of the same family which has occurred as a straggler in these islands.

The **pigeons,** Family *Columbidae*, are widely distributed all over the world, being particularly well represented by numerous species in the Eastern Hemisphere. They are considerably varied in size and colour. Most show some metallic lustre in the plumage, and some are very brilliantly coloured. All may be readily recognised by the slender bill, with its soft cere at the base. They build a loose nest of sticks, laying usually two white eggs. The cooing habit is also a family characteristic. The young when hatched are at first naked as well as blind and helpless; soon, however, they develop a hairy-like down.

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* Data compiled from Stainton's *Manual of British Butterflies and Moths*.

Mammalia.

The **hedgehog,** *Erinaceus europaeus*, is one of the few representatives of the Order *Insectivora* occurring in Britain. The other native types are the **mole,** *Talpa europea*; the **shrew,** *Sorex araneus*; the **pigmy shrew,** *Sorex minutus*, and the **water shrew,** *Crossopus fodiens*. As the Ordinal name suggests typical members of the group feed upon insects, although not exclusively In general the tubercles of the back teeth are not blunted but adapted to cut the chitinous coverings of the food. Those depending most largely upon insects for food are hibernators; these are hedgehog, shrew, and pigmy shrew.

QUESTIONS ON CHAPTER IV.

(SUMMER : ANIMAL STUDIES.)

1. Describe the general appearance of a hedgehog. How does it pass the winter?

2. Name two other animals belonging to the same group as the hedgehog. What is the general nature of their diet.

3. How many kinds of wild pigeon occur in Britain? Name them.

4. Describe a wood pigeon. Name some things it feeds on. By what other names is it known?

5. Describe the nest of the wood pigeon. How many eggs does it lay? What are they like?

6. What are the "marks" of a rock pigeon?

7. Make a drawing of a starling.

8. Mention four facts of particular interest in the life of starlings.

9. Describe a starling's egg.

10. Describe any five birds' eggs (not white) you are familiar with.

11. Name four birds which lay a white egg, and one which lays an egg resembling the surroundings of the nest or the nest itself

12. What are the uses of the shell upon a bird's egg?

13. Make a drawing of a section of an ordinary fowl's egg showing all the parts, and naming them. What are the uses of the "chalazae"?

14. Name ten small animals living in fresh water.

15. What is *Gammarus*? Upon what does it feed?

16. How do mayfly larvae breathe? Compare this with the breathing of a larval gnat.

17. Where do "pond-skaters" live? Upon what do they feed? What Order of insects do they belong to?

18. Name one distinguishing feature about the pond snail, *Lymnaea*.

19. Write an account of the habits of whirligig beetles.

20. Map out the life-history of the frog in six stages, assigning to each an event of progressive significance.

21. What is happening within a tadpole when it begins to push its head out of water?

22. Describe how the fore limbs appear in the tadpole as it develops into a frog

23. Describe three structures of special interest in a worker bee.

24. Give an illustration of an instinctive action from the life of a worker bee.

25. Make a drawing of a caterpillar, filling in as many details as you can and name the structures represented.

26. What is "moulting" due to? Sum up in a sentence the life of a caterpillar.

27. Explain the term "larva." What kind of insect has a caterpillar for its larva? Name other two larvae you are familiar with.

28. Give two examples of protective behaviour from the life of the larva of the magpie moth.

29. Draw a cabbage butterfly in its resting position, naming as many parts as you can. Compare its external structure with that of a caterpillar.

30. Upon what do butterflies feed? Do they moult? Explain this. Compare the life of a butterfly with that of a caterpillar.

CHAPTER V.

PLANT STUDIES IN AUTUMN.

LESSON XLI.

THE HAREBELL (*Campanula rotundifolia*).

[A plant common by the waysides, flowering from July till beginning of September. Give each pupil a flower, if not an entire plant.*]

The harebell—known in Scotland as the "blue-bell"—is a familiar plant of the banks and waysides, where its nodding clusters of graceful and delicately coloured flowers form a pleasing feature. The plant is suggestive of lightness, the stems are slender and wiry, the leaves are mostly narrow, and the flowers are graceful in form, fragile and tender in appearance. While growing, they keep their freshness and beauty for some time, but plucked they will become limp and fade away in an hour. Placed in water they keep much longer, but the warm air of a room is never very favourable to their vitality.

While we study the flower minutely indoors, let us not forget the charm of it growing in the open. Tell where you have seen them growing, if you have ever gathered them, and what you think are their special attractions (Fig. 106).

Colour and Shape of Flower.—Let us look closely at a single fully opened flower. Outside there are five slender spreading sepals, and below these the ovary. Notice the perfect bell-like form of the corolla, with its five-tipped slightly spreading margin. Examine its substance carefully. It is soft and faintly "crinkly," so thin that the light filters easily through it, delicately coloured a **soft blue.** A clearly formed thin line of darker blue runs down the bell to each of the five tips. You will see it clearly if you look for it. All the **flowers droop** on short and slender stalks, except one which forms the end of the main stem.

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* See note at end of Lesson XLIII.

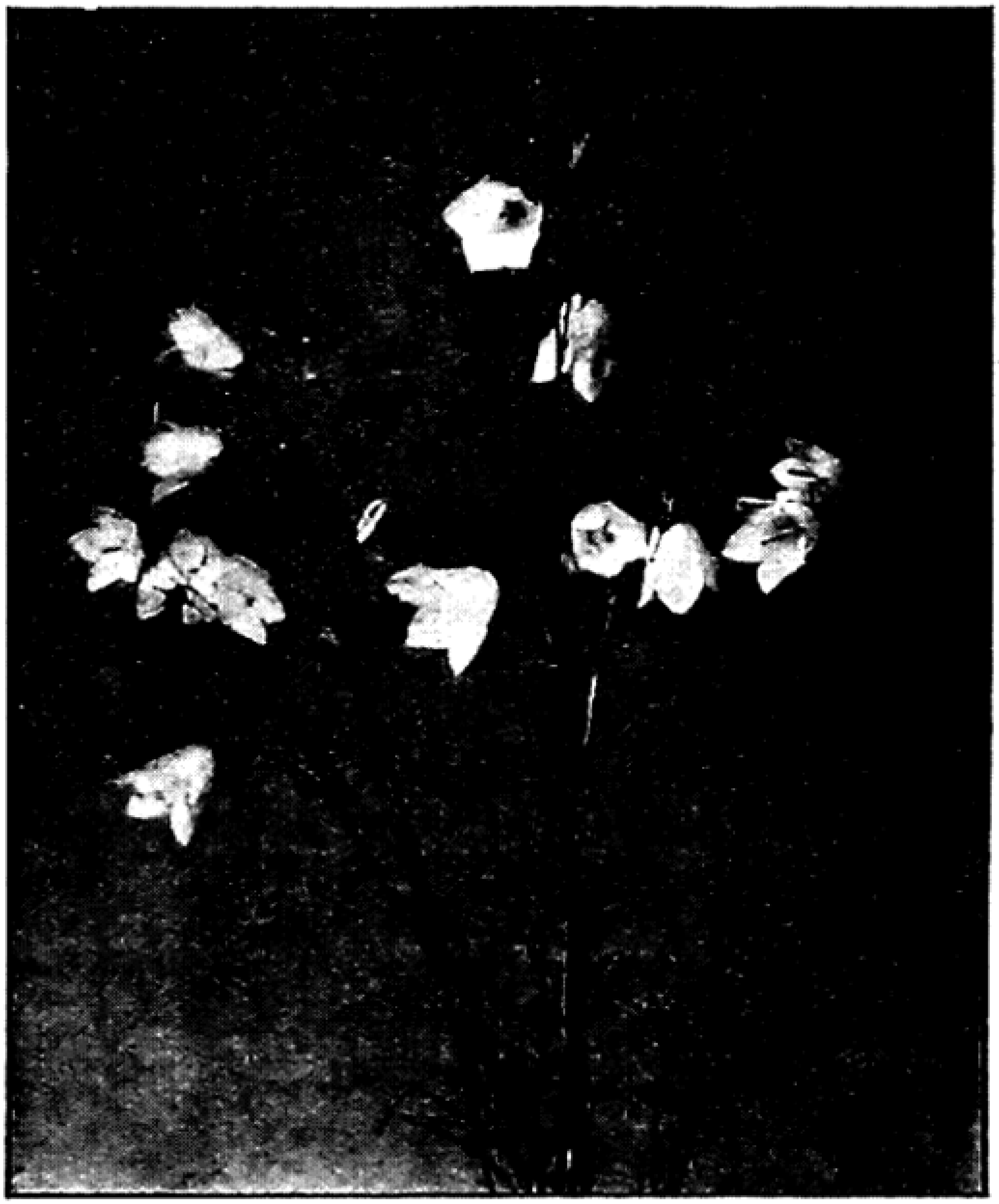

Fig. 106.—The Harebell.

You will best understand the inner parts of the flowers if you examine a few at different ages. You may get all these upon the same plant.

Stages of the Flower.—Examine a flower in the **bud** stage. In passing you may note the manner in which the corolla is folded with five projecting ridges. Remove the corolla, note the position and condition of the stamens and pistil. Describe what you see. There are five erect light reddish brown anthers upon short filaments surrounding a short central single-tipped pistil of about the same length. You may find that the anthers are already maturing, and that the pollen is falling upon and adhering to hairs which encircle the pistil behind its tip. If you see this write it down in your note-book.

Examine next another flower expanded but showing the stigma still with a single tip or just **dividing into three.** In this flower observe that the pistil is much longer, it carries a good deal of pollen upon the hairs behind the stigma, and the stamens are standing back against the corolla or have begun to curl up and wither.

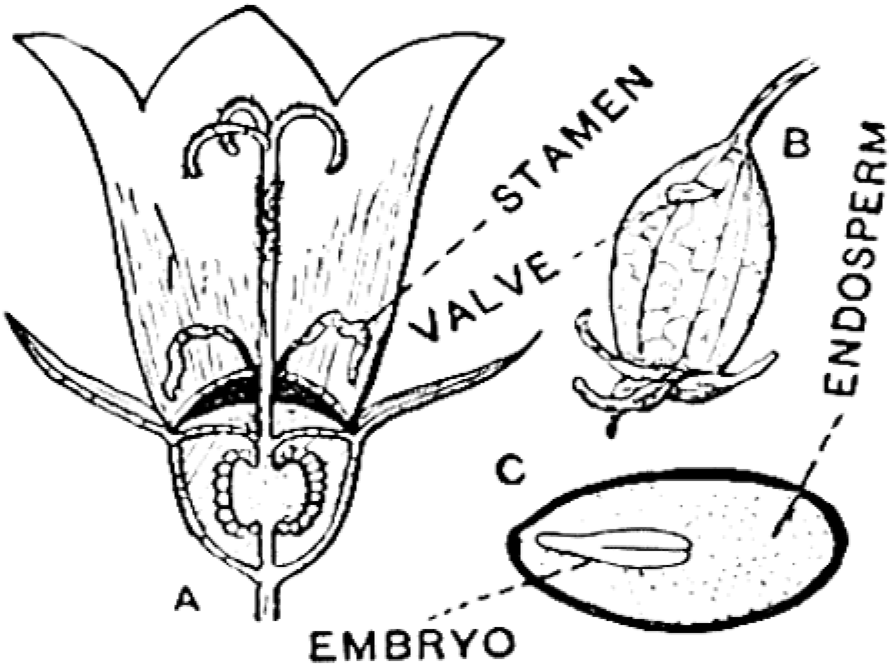

Fig. 107.—*Campanula.*
A, Half-Flower ; B, Fruit ; C, Longitudinal Section of Seed.

A third stage of the flower will also be found. The stigma is here coiling outward and backward in three parts. The stamens are curled up withered at the bottom of the bell. You may even see the stigmas as they coil backward touching the pollen-covered hairs upon the pistil (Fig. 107). You should make a point of observing this.

Insect Visitors.—Various insects visit these flowers, some for pollen, *e.g.* **Eristalis,** a hover-fly (p. 289), others for honey **(bees)** which they get upon the top of the ovary in the base of the flower. You must think over the facts you have observed in the different flowers you have looked at in connection with these insect visits.

Pollination.—You will see that, since the pollen is mature and shed largely before the stigma is exposed, self-pollination is for a time prevented, and that in many instances insects in passing from younger to older flowers will effect cross-pollination. Notice, however, the provision for self-pollination in cases where insect visits fail. The stigmas in curling back touch the pollen which has adhered to the hairs upon the pistil and in this way self-fertilisation results.

Examine the bases of the stamens. What is their shape? Describe the margins where they meet each other. Can you think of any service that this arrangement performs in an open flower with nectar at the bottom? What is the advantage to the flower in having drooping bells?

Still another stage of the flower is worth looking at—the **withered flower.** Do the petals fall off? No, they remain in a shrivelled state covering the fruit. Remove the corolla, and for a moment look at the fruit. If you can get a plant in an advanced stage you will see the way in which the seeds are scattered. The fruit remains upon the stem and is shaken by the wind. Small openings occur near its base and out from these the small seeds are jerked (p. 255).

Draw a harebell plant.

For a second lesson, **Lobelia** may be taken. Compare as to shape of flower and the relations of its parts.

LESSON XLII.

THE MONKSHOOD (*Aconitum napellus*).

[This is a common garden flower with which the children will probably be familiar. Let each pupil have a single flower. Have flowers of different ages. Tell the pupils where they may see an entire plant after the lesson is over if they do not know it.]

This is a very familiar flower of characteristic appearance well known in gardens. Its tall flowering stems, carrying their long series (racemes) of large blue flowers, are always conspicuous wherever the plant is placed.

Shape.—It is easy for us to trace the origin of the common name; we find it in the peculiar shape of the flower. There is no doubt that the shape is one of the most interesting things about this flower. Let us consider it for a little. The best way to understand its meaning is to spend a little time beside a monkshood plant on a warm day in July or August when the flowers are fully expanded. What are we likely to see? Many insect visitors. If you have seen them you will know the kind of insect, viz. **humble bees.**

What do you see them do? They go right inside the flower. Indeed, the flower and humble bee **fit each other** extremely well, both in shape and size; they are, as we say, adapted to each other. They are in fact adapted to each other so completely, not only in size but in other things, that it seems the monkshood plant cannot exist without the humble-bees. It is certainly true that monkshood plants do not exist wild where there are no humble bees, and, further, that they have spread into almost every part of the world where humble bees occur.

When we watch the bees visiting these plants we see them almost disappear inside the flowers. They do not usually stay very long, so they must get what they seek, viz. nectar, quite readily. Further, it must be placed high up within the flower. Is not this unusual? Generally we find the nectar somewhere down in the base of the flower, and that the insects grope downward. In this flower we can see the base is quite close to the opening, stamens and carpels protruding outward at the entrance, and that the insects pass this region by. It is not near these that the sweet fluid is to be found. If you have not observed this, watch the bees at work upon the flowers.

Make an outline drawing of the flower seen from the side. Then carefully remove the overhanging hood-like part without disturbing any other structures. Now you see clearly a pair of fine looking staff-like bodies, each with an elaborate "handle" at the top. If you remove one of these and examine it closely you will find that the top is hollow and that there hangs within it a drop of nectar ready to be sipped by the first bee that comes. Thus you have discovered that there are **two nectaries** of a very special form in the monkshood. You should make a careful drawing of one (Fig. 108).

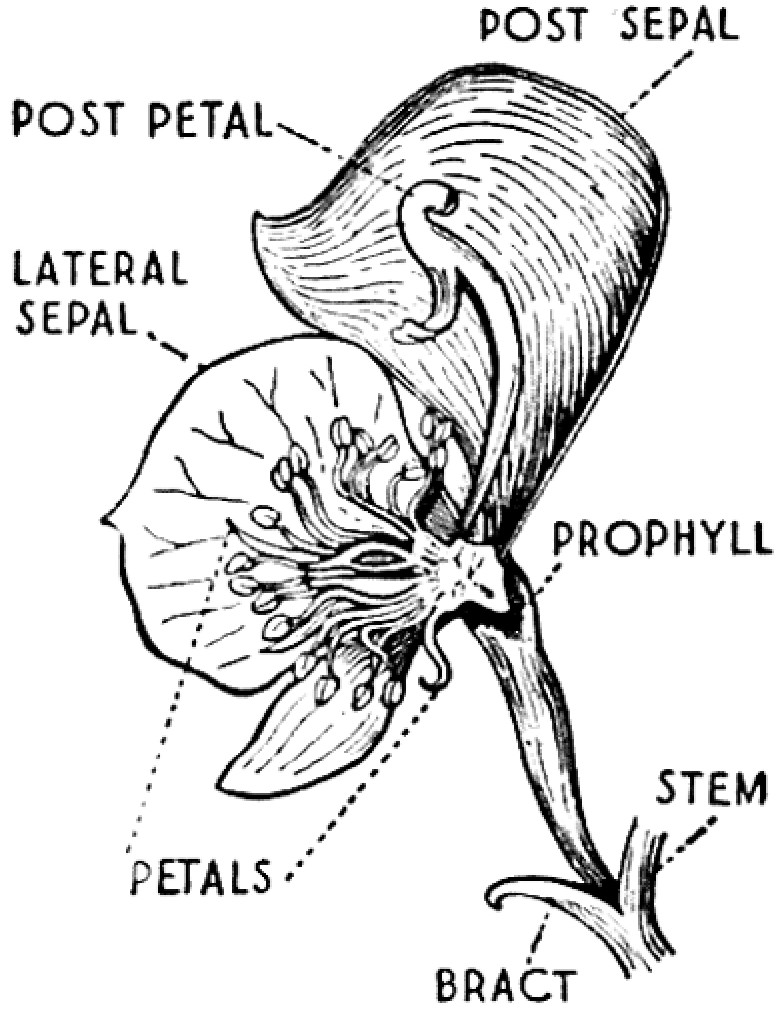

Fig. 108.—Half-Flower of *Aconitum.*

What the Bee Does.—Now you will see that before a humble bee can reach inward so as to push its sucking apparatus into this nectary it is bound to be *rubbing the under side of its body all the time amongst the stamens and stigmas.* It will constantly be gathering pollen there and constantly rubbing it off. The result, however, is not a random scattering of this substance but an orderly causing of **cross-pollination.** Observe now **how this is brought about.** In order to see this you must have a number of flowers of different ages. You will easily get all you require from a single plant. Examine these, noting the appearance of the stamens and stigmas.

You will not have to do this very long before you discover interesting differences depending upon age. In some you will find the stigmas almost completely concealed amongst the stamens, and in these some of the stamens have their anthers turned backward and others have them projecting outward in front. These standing forward are shedding pollen, and if you compare a few flowers of this stage you will easily discover what is happening. **State what you see.** The stamens at first have their ends turned back, and as they become ripe they become straight. In flowers at this stage bees get pollen on to their bodies, but they cannot leave this upon the stigmas of the same flower, nor would it matter at present although they did, for you see this part of the flower is not yet ripe, and the pollen cannot act upon its surface.

Can you recognise the next stage in the growth of this flower? After the stamens have shed their pollen they bend away from the front again and wither. By this time the carpels are ripe and the stigmas standing up in the entrance, so that in the flowers at this stage the bees do not gather pollen but, bringing it from younger flowers, leave it upon the stigmas, and thus they cross-pollinate the flowers. As all the flowers are likely to be visited a number of times, both when they are in their younger and later stages, there is not much chance of any of them missing being pollinated.

Now you must make two drawings of the central part of the flower so as to show first the stage in which the anthers are clustered in front, and second the stage of mature carpels with withered stamens around their base. You must carefully examine the flowers at different stages so as to draw these correctly.

The Structure of the Flower.—In handling this flower have you not noted the absence of green sepals? You see there is no such thing. The **sepals are present,** but they are not green. In the monkshood they are coloured so as to serve for attraction; the upper one is so conspicuous that it is readily seen by the humble bees. It is further very useful by its shape protecting all the other parts, especially the nectaries and stamens. Observe the lower sepals which also serve to attract.

Can you think what is the real nature of these elaborate

nectaries? These **are petals.** So you see how very different is the monkshood from most flowers. Its sepals not only do their own work, viz. that of protecting the parts within, but they do the work of petals also (attracting). The two upper petals, concealed within the overhanging hood, deprived of the need for being conspicuous, have become the nectar-producing organs which have made the plant so **much sought after by humble bees.**

Honey Thieves.—Sometimes one finds flowers of the monkshood with a small round opening on the side of the hood just opposite the nectary within. Look amongst your flowers and you may be fortunate in finding one. Can you think of the meaning of this opening? This hole is the work of a "robber" bee. There are bees which, owing to their small size or shortness of their tongues, cannot reach the nectar by entering the flower in the usual way. And rather than miss it, they cut a hole in the hood, and passing in their "tongues," secure it from the outside of the flower. But this does not do the flower any good, and honey got in this way we must describe as stolen and the bees as honey thieves.

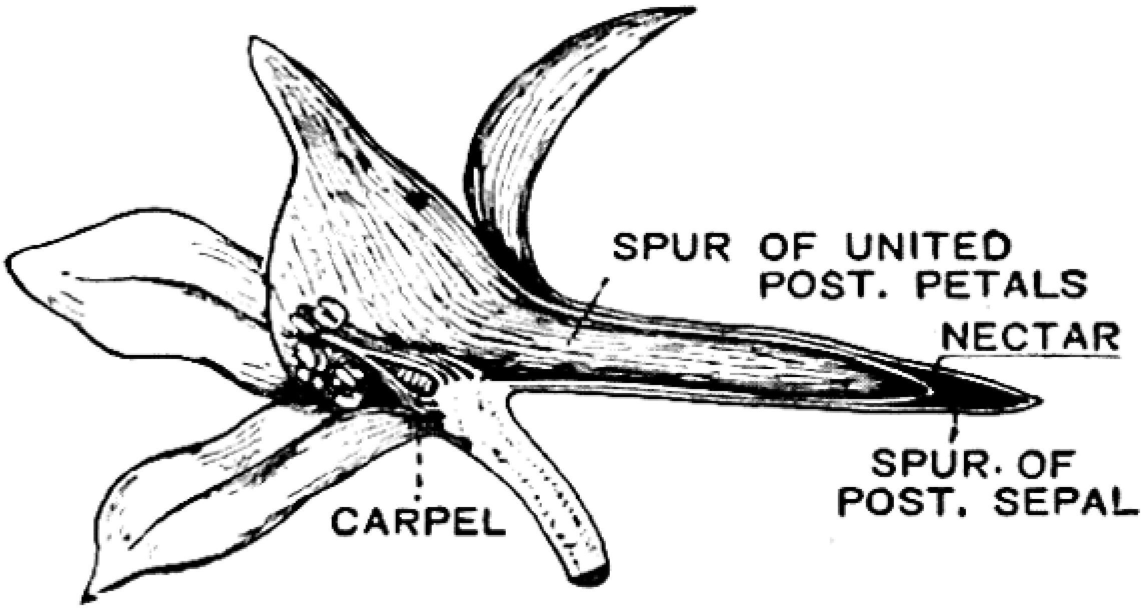

Fig. 109.—Half-Flower of Larkspur.

The Fruit.—Have you looked at the fruits of the monkshood? Note their pod-like shape and arrangement in clusters of three or more. How do we distinguish this kind of fruit from a true pod? By the way in which it opens. This fruit opens along one edge, viz. that to which the seeds are attached, and then the **wind swaying** the whole plant shakes out the seeds to fall some distance away. This kind of fruit is termed a **follicle.**

A second lesson may be given upon the **larkspur** (*Delphinium*) whose arrangements for pollination by long tongued insects are similar. Here there are also petaloid sepals, five in number. The posterior one has a spur containing two spurred nectar-secreting petals (Fig. 109). Flowers of different ages should be examined and compared as suggested above, and the method of pollination deduced. Observations of insect visits should be carried out wherever possible upon the growing plants.

LESSON XLIII.

THE HONEYSUCKLE (*Lonicera periclymenum*).

[The teacher should endeavour to find specimens illustrating as far as possible the facts recorded in the lesson. It will be necessary to make a series of clear drawings representing the successive stages of pollination.]

General Facts of Interest.—There are a number of interesting things about this familiar plant which we shall think of for a little. Our attention is first drawn to it, is it not, by the somewhat peculiar **shape of its flowers** and the way they are grouped (Fig. 110). Then its **name** is interesting, suggesting to us that it is specially **rich in nectar** or honey, and we early discover that its flowers have a delightfully **attractive odour,** especially in the evening. Perhaps besides these things you also know some others about this plant, such as its **climbing habit,** its **hollow twigs,** or its putting forth of its **leaves early** in the year.

A Flowering Branch.—We shall try, by examining portions of a shrub, to learn a little more about the honeysuckle. Let us look first at a flowering branch. It is more or less deeply coloured, has opposite leaves, and bears at its end a closely clustered group of flowers. If you can draw a twig with its flower-cluster you should do so, but if not draw a few flowers singly.

Inflorescence.—The flower-cluster includes, as you can see, a number of very small leaves as well. What name do we give to the leaves of a flower-cluster? They are known as "bracts." Are all the flowers in a cluster (inflorescence) the same size or age? No. There are small and large; some—the smaller ones—are immature, the larger ones are older. Is there any general arrangement of old and young flowers? Yes, the younger ones are lowest down, nearest the outside, the ripest and most fully opened flowers are on the top.

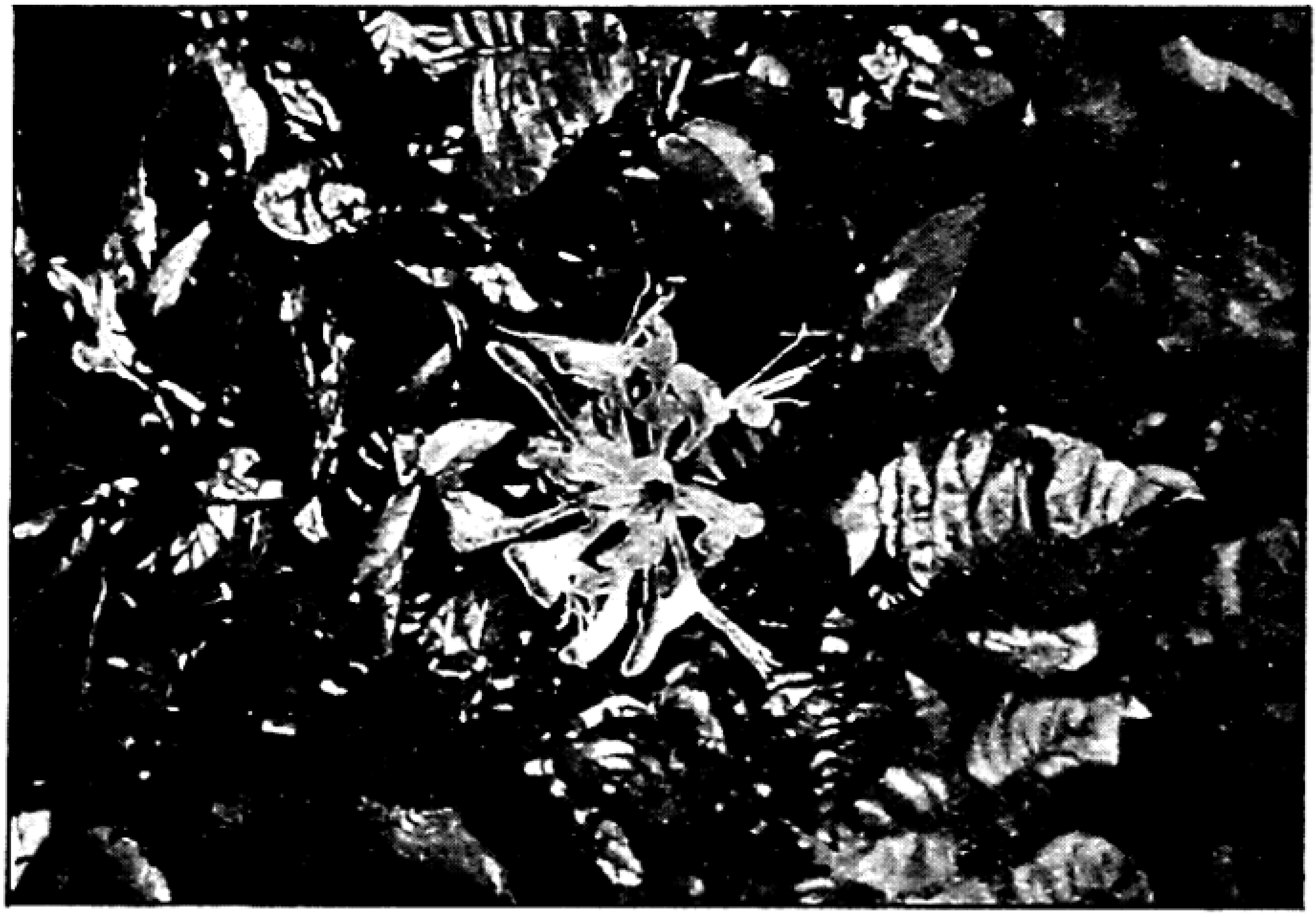

Fig. 110.—Honeysuckle.

Flowers.—Will you examine one of the **unopened flowers?** Select one which you think will open soon. How is it standing? I think you will find it in a more or less **erect** position. There is a reason for this, as we shall see presently. Have you carefully drawn this flower? If so you will have discovered its exact shape—a double curve, with the curve nearer its tip wider than the one lower down. If you remove it from the cluster you will likely find that the calyx of five parts is left behind. Of how many parts is this long curved tube-like corolla built up? You can see in this flower that it is preparing to split into two, that the bulging part is opening along the two sides. Now you might gently, with the help of a pin, open the flower towards the tip along the lines of the natural split (Fig. 111).

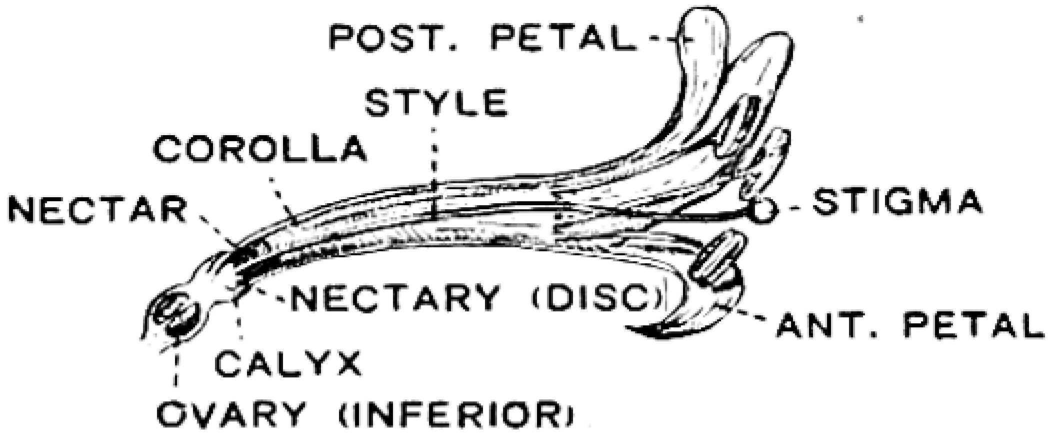

Fig. 111.—Longitudinal Section of Flower of Honeysuckle.

What do you find? The first things likely to attract your attention are the five anthers. They are large, they are situated a little way from the end of the tube, and they are **shedding their pollen.** You will find this to be the case if you have chosen an unopened flower about the last stage. Do you see the pistil? Yes. It is longer than the stamens, and its stigma is enclosed in the cavity at the tip of the flower formed by the broader division of the corolla.

Can you think why the unopened flower stands erect? This arrangement prevents the pollen falling upon the stigma—which is also ripe, as you may see by examining it with a lens. When the lower lip of the corolla has separated naturally, the stamens gradually stick out from the opened flower, while usually the stigma continues held by the hood at the end of the upper lip. I shall describe to you what skilled and careful observers have seen to happen next, and if you look carefully at the flowers beside you or on a growing plant you should see something of the same kind yourselves.

After the stage just described the **flower slowly changes its position,** turning downward until it is horizontal. Meantime the stigma has escaped from the upper part ot the corolla and bends down, following the downward curving lower part clear below the stamens It does not touch these because the style is longer than the stamens The stamens stand straight out in front of the mouth of the tube, the anthers having their pollen-shedding surfaces turned outward. You will notice that the anthers have a very slender attachment (versatile), and shake out the pollen readily. The flower is now **emitting a strong and pleasant smell,** and is exposing the glistening white of the inside of the corolla. This is known as the **male stage** of the flower, and is exhibited on the first evening the flower opens. Draw a flower at this stage.

The **next morning** the style is found to be undergoing a change of position, moving upward; by the end of the day it is above the stamens with its tip turned upward, and these have bent downward, their anthers shrivelled. This is now the **female stage.** You will see at once that if a moth, for example, visits the flower at this stage, having previously visited a flower in the male stage, the under side of its body will already be dusted with pollen which will be transferred to the stigma, and thus cross-pollination be effected.

Other interesting things besides the change in position of stamens and stigma have taken place during the day. Both parts of the corolla have rolled back more completely, the insides have **changed colour from white to yellow,** the result on the whole being that these second evening flowers are less conspicuous than are those just opened and showing pure white.

Examine all your flowers and try to recognise the different stages here described.

Let us try to grasp the meaning of all this. The most successful visitors to the honeysuckle are the **hawk moths.** They are keen of scent and are attracted to the honeysuckle by the strong fragrance it gives out in the evening. As they come near, the brightly coloured flowers—first the whole cluster, and then the individual flowers—draw them. Of these, the larger red and white examples are more likely to attract first—that is those in the pollen-shedding stage. There, in probing for the honey, they become dusted on the body with pollen, but do not touch the stigma, which lies out of the way. They next visit the flowers in the yellow or female stage, with the result that, as already noted, cross-pollination follows.

The flowers in the second stage continue so for some days, still secreting a little honey and giving out a faint fragrance, being still capable of pollination if that has not been previously effected.

Besides hawk moths, **other moths** and **humble bees** visit the honeysuckle for nectar, and sometimes pollinate in doing so. **Hover-flies** (*Syrphus sp.*) visit the flowers in the early stage for pollen—their tongues are too short to reach the nectar—and as they sometimes touch the stigma accidentally they may also effect cross- or self-pollination.

Have you noticed the fruits of the honeysuckle? They form clusters of dark red berries. Look out for them in the autumn.

For a second lesson on this plant you should examine the remainder of your twig, noting the colour, the leaf arrangement, the triangular buds with their loose scales, the shape and texture of the leaves. Cut the twig, and note the hollow down the centre of the pith. Find a twig of the elder tree, another member of the same Order, and write down a list of the characters in which they agree and in which they differ.

Make as many drawings as you can to show the things you have observed.

The pollination studies of the three foregoing flowers are rather more difficult, and involve careful and deliberate examination and drawing of suitable stages in each case. The teacher should not hurry over these. Further, the lessons, as far as examination of material is concerned, may profitably be repeated if suitable specimens can be got.

It will probably be advisable to divide the lessons as given into several parts and to summarise the whole study when the examination has been completed.

LESSON XLIV.

THE HARVEST OF THE WAYSIDE.

[The observations quoted below are such as a teacher might make on similar rambles to aid pupils in writing a description. They further contain material which teachers may profitably utilise for individual lessons on particular subjects.]

General Description.—On every hand, as we set out upon our ramble, are fields rich with an abundant harvest of ripening grain. Overhead is blue sky flecked with great banks of fleecy cloud, the air is warm and still, the grasses by the roadside sway but lightly, and bird-life, for the nonce, seems silent. There are sounds to be heard; **grasshoppers** are "chirping" amongst the herbage by the wayside, an occasional **droning bee** or heavy **hairy fly** buzzes past us, but they serve only to make the silence more felt. It is a sleepy afternoon.

In front of us is the long white dusty road, margined on both sides by a persistently encroaching vegetation. Hidden amongst the rank growth of this neglected roadway on each side is a fairly deep "ditch." In one of these there runs, sometimes the whole year through, a little clear streamlet, not big enough to be termed either brook or burn, but fertile all along its course with a rich variety of **grasses** and **other flowering** plants, **ferns** and **mosses.** To-day the stream is dry and must have been so for some weeks, for in its sandy bed the **meadow buttercups** and other strictly terrestrial weeds have gained a temporary hold, and we are able to walk along its track and scan all the more closely the thick growth upon its banks.

The roadside has for the most part a sombre look. A prolonged drought has robbed it largely of its greenness, and further the season is autumn, when the brightness of the summer wayside flowers has mostly given place to less conspicuous and **duller-coloured fruits.** Tall grasses abound, their dull grey predominating, although interspersed throughout are dots of brighter hue. There are plenty of specimens of the *Centaurea nigra*, **black knapweed,** some of which are still in flower, displaying their well spread-out pinkish-purple heads, whilst others are in the dull brown fruiting stage. Another common plant here, blue in colour, is *Scabiosa succisa*, the **devil's-bit scabious.** Both of these are receiving marked attention from **humble bees, hover-flies, cabbage white butterfly, small copper butterfly,** and other insects.

Mingling in the crowd are tall examples of *Senecio jacobea*, the **ragwort,** some of whose golden yellow heads we stop to watch being systematically rifled by numerous hover-flies of the species *Eristalis tenax*; others have passed the flowering stage and are displaying their tiny dull white **downy spheres** of fruit to both sun and wind, courting dispersal.

Nearer the road plants less erect add their share of colour. There are numerous *Hypochaeris*, **cat's ear,** in both flower and fruit, the familiar *Potentilla tormentilla*, the **tormentil,** *Lotus corniculatus*, the **bird's-foot trefoil,** a stray *Ranunculus acris*, the **meadow buttercup,** and *Galium verum* (**ladies' bedstraw**), each contributing its touch of yellow; a few examples of **yarrow** (*Achillea millefolium*) and of **sneezewort** (*A. ptarmica*) are still in flower; here and there are **harebells** adding their touch of blue, while an odd blossom of the **bramble,** lingering white amid the **ruddy, blackening fruit** makes up the tale of plants whose flowers still brighten the wayside. Along this stretch of roadway there is but one gleam of red—not of flowers, however—a solitary wild rose plant, decked abundantly with **scarlet fruit.**

What green there is, is displayed mostly by the larger and stronger plants. Bramble plants are common by this roadway, with foliage mostly fresh, though a stray leaf is mingling brown and crimson with the green; **broom plants,** rustling, many podded, add their black and green, **bracken** in abundance fills the drier ditch in many parts, tufts of **male fern** break out fresh from between great boulders banked up behind the ditch, and here and there **rowan trees** young and fruitless are struggling up through rough and stony soil.

As we have said, the roadway, despite the glimpses of bright flowers interspersed amongst its herbage, is rather sombre. The green even is at best the green of autumn—a somewhat dull colour—a bit soiled and dusty; torn, some of it and "worm" eaten. But if the brightness of summer flowers is wanting, what **a profusion of fruits and seeds** is here!

Search for Fruits and Seeds.—What are these slender black-looking plants massed in great numbers along the top of the bank next the fields? These are **ladies' bedstraw** plants. Let us each pluck a specimen and look at it closely. The black appearance is due to the masses of small rounded and finely-wrinkled fruits. Each single plant bears a very large number, as you can see, too many for us to count by the wayside. I have here a number of pill boxes, and we shall put in one all the fruits of a single plant, label it, and put it aside for future study.

Meantime, we can see that a good crop of bedstraw is likely to fringe this bank next summer. For you note the stems have become dry and wiry, and that the fruits, which are quite ripe, break off easily when handled or shaken. The wind will shake these to the ground and the rains or melting snows of winter will wash them into the soil. Doubtless many will fall in unsuitable places, and others will be eaten by birds, but for all that a good crop of bedstraw is ensured for the coming year.

Near by the withered-looking bedstraw are taller, dark green, wiry-looking plants. They bear green or dry creamy-looking wrinkled fruits to which there adhere the pale, shrunken, and withered corollas of the previous days. These plants have many marks of identification, and we are able to say what they are even although we have not had time to notice that some of them are still in flower. These are **harebells.**

Notice here the way in which they shed their tiny seeds.

We gather some fruits and examine them closely. Those which are still green show no openings, but around the base are little pits or depressions; in the drier and lighter coloured examples you will find the pits have opened into small pores (Fig. 107). We shake a plant as the wind might do, and see that through these pores are flung for some distance the tiny seeds. Before the winter comes the crop of harebell seed will be sown, some of it in "good" ground, and some of it there is no doubt whatever to perish. We shall put some fruits in a pill box, both unripe and ripe. We shall open the unripe ones early and examine them with a lens. In this stage the seeds are of a charming crimson colour which dulls to brown with age.

Near by, just behind the bank close to the side of the cornfield, are some **dock plants** in full fruit. In shape like a lombardy poplar in miniature these common and troublesome weeds look really handsome. Erect in habit, clothed intensely in the brown of autumn, they possess not a little suggestiveness of beauty which we welcome in such generally despised plants. Here specially we note the large numbers of fruits, each containing one seed, which a single plant gives rise to. Our pill boxes are fairly large, but no pill box has ever been made which would carry one-fourth even of the fruits of a single dock plant. Nature's harvest here is more than bountiful!

Let us for a moment stop to look at the single fruits. Note the fairly large enclosing membranes, three in number, presenting their edges to the wind. As we shake a plant, we see how the wind can first of all strip them off, and afterwards blow them about. These membranes are remaining traces of the flower. They were originally petals. Note the clearly-marked network of veins upon them all, and upon one in each fruit observe the little oval growth or tubercle. If you remove these scales you will find the fruit, a small three-cornered, finely polished little brown nut.

There are a good many other plants by the wayside whose fruits have been borne here on the wings of the wind. Look at those tall **thistles.** They are all of them past flowering, and in various stages of ripening fruit.

Here, as always on the wayside, is an abundant harvest sure.

Look at these whitening heads. There is no wind to-day, and so far we have not seen a single "thistle-down" floating in the air; but the sun is getting things ready. Have you noticed the **share of the sun,** not simply in ripening the fruit, but in the case of thistles and other plants with hairy parachutes upon their fruits, in swelling them and causing the hairs to spread out to form those elegant downy spheres which later are caught upon the wind? To-day we see the sun expanding those thistle heads and spreading out their down.

Ragworts and **cat's ears** are also undergoing the same process, and even the dense heads of the **black knapweed** are expanding and loosening in the genial warmth. In the coming days these plants will sway in the wind and fling their tiny fruits on every side. Here, close at hand, is a solitary plant of the **mouse-ear chickweed,** whose fruit capsules, margined by ten tiny teeth, now gape empty, having already, swaying, swung away their seeds. After this manner also do the **grasses,** which are here in such profusion, scatter their numberless single-seeded fruits, swelling abundantly the wind's mixed sowing of the wayside.

This roadway has a sunny and a shadier side. Upon the latter, whose ditch is also stonier, bracken ferns have gained a firm hold. A few years ago there was no **bracken** here, but to-day it flourishes abundantly. Having gained a place, it has rapidly spread. One good reason for this we can see in the **multitude of spores** which each plant produces. Spores are comparable to seeds as regards their function, viz. reproduction, although these two differ vastly in actual structure and in relation to the other parts of the plants producing them.

Look at the back of a mature frond of bracken. Along the margins of each pinnule (p. 276) you can see the close-set continuous row of minute brownish bodies. Take a good magnifier and look at these. Very minute shiny-like bladders they are. These are not, however, the spores, but the sporangia or spore-containing sacs. Within each of these there may be as many as sixty-four separate spores, each capable, under suitable conditions, of giving rise to a bracken plant.

Take a well-matured branch of a frond home, lay it out upon a sheet of clean paper, place another sheet upon the top, and cover over with something just heavy enough to keep things in their place. Do this in a moderately warm room, and after twenty-four hours carefully lift first the covering and then the fern from its place. You will now find upon the paper below an outline of the frond, traced in fern spores. Look at them with the best hand-magnifier you possess. Beside these exquisitely minute bodies, grains of the finest sand are as coarse boulders—they are at least several hundred times bigger. Put back the fern frond upon a fresh sheet and repeat the experiment, and you shall have a fresh crop of spores upon the morrow—for they are not all shed at once. Can you *imagine* how many spores a single fern plant produces? There is nothing we shall see on all the wayside whose progeny is so vast.

How are these spores dispersed in Nature? The sun first plays its part. Under its genial warmth the ripe sporangia burst and fling out the tiny spores. Many will still adhere to the parent plant, and others float like tiny motes gently to the ground—but they may go a good long way first. Sooner or later the fronds wither and are beaten down by wind, rain, and snow to the ground. Countless spores are washed away—buried too deeply into the soil ever to rise again—many are carried into places where other vegetation has already gained too secure a hold to be displaced, and many will germinate only to be choked out at a later stage.

After all only a few survive, and that may be more than enough. For if from a single bracken plant but *two* spores succeed the number of bracken plants will be trebled, and this means on the crowded wayside the displacement of something else, and this is not always easy.

On the same side of the roadway are many **broom** plants. Their golden glory of summer has given place to the **dried and blackened pods.** Most of these are already burst and the seeds have fallen to the ground. You are familiar with their mode of dispersal. Have you noticed after a day of warm sunshine, when the rays of the sun no longer fall directly upon the broom, how the pods "explode"? Cooling slowly after the heat, the pod is split by the tension of contraction, its halves jerked apart and the seeds thrown out. Observe the multitude of pods, each having scattered its long row of seeds, and try to think whether many are likely to grow up into fresh plants alongside the parent.

Another plant of the same order, scattering its seeds in the same way, is growing close to the margin of the other side of the roadway. This is the **bird's-foot trefoil,** with its long, well-filled, narrow, and rather striking-looking pods. Each pod contains from about fifteen to twenty seeds, and the total number of seeds from any single plant is very much fewer than those from a single broom plant, yet the number of separate bird's-foot trefoil plants here is very much greater. There are many reasons for this; can you think of some of them?

Well hidden below the overshadowing bracken fronds we discover a spreading clump of **sweet violet** plants. They are interesting at this stage because of the way in which their seeds are dispersed. Some of the fruit capsules have already opened and stand horizontal, empty, split to their base—triradiate. Let us take a fruit, not quite mature. It is three-angled. A gentle pressure causes it to split into three parts, dividing along the middle line of each flat face, and forming three boat-shaped bodies packed to the full with glossy white egg-like seeds. It is the gradual contracting of the walls of the capsule in ripening, pressing the smooth seeds together, which causes them to jerk out of these boat-shaped parts formed by the already split capsule. And thus they join also the already goodly company of seeds seeking rest and awakening in the vitalising earth.

There are many other plants each adding its quota year by year to the seed harvest of this roadside—

daisy, buttercups, self-heal, tormentil, sheep sorrel, plantains, knotgrass, yarrow, sneezewort, queen of the meadow, a stray **heather** plant almost submerged amongst the grasses, and on the other side of the dried-up streamlet a solitary **blaeberry** plant.

Besides this single specimen there are only a few other plants with edible fruits. These are the **wild raspberry, bramble,** and **wild rose.** Perhaps because their fruits are largely dispersed by animals and human beings their seeds are carried further afield, and fresh plants are less likely to spring up near the parent. Over a half-mile of roadway there is only the one wild rose plant. But there is doubtless more than one reason for this.

LESSON XLV.

EXERCISES FOLLOWING A WAYSIDE RAMBLE.

[After a ramble in search of wild fruits to provide materials for a series of lessons, make the class work through the following exercises.]

1. Give a general description of the wayside as you saw it on your visit.

2. Examine a collection of fruits found on such a ramble. Group them according to their modes of dispersal, *e.g.*

By wind—(*a*) fruits having wings, *e.g.* dock; parachutes, *e.g.* thistle;
(*b*) shaking of plant, "censer" arrangement of fruit, *e.g.* harebell, or without it, *e.g.* knapweed.

By "explosion" of fruit—broom, viola, etc.

By animals—(*a*) fruits or plants adhering to their bodies;
(*b*) fruits eaten and seeds dropped or otherwise scattered.

3. Make a set of representative drawings of the various fruits found.

4. Make a list of the ten plants you think are most numerous upon the wayside. Write them down in the order of abundance. Compare your conclusions with those of your fellow pupils.

5. Describe clearly the arrangements for distribution in any two fruits you know.

LESSON XLVI.

THE TREES IN AUTUMN.

Autumn Tints.—We have watched the changes gone through by the trees in the earlier seasons of the year. Autumn has now come, and with it trees are slowly displaying, in response to its influence, their golden and ruddy tints. Our studies of these must begin with watching day by day, or week by week, the progress of the autumn changes. As you do this you will learn to delight in their **colours** and to value more and more the beauty of the trees. Notice the gradual growing in intensity of the autumn tints, and when these are in their most pleasing aspects you are to try and describe them.

Descriptions.—Write a short account of the appearance of the trees in your neighbourhood in their autumn dress. Your teacher will direct you as to the best time to do this. If you can go out as a class for the purpose of looking at the trees and comparing them from the point of view of the beauty of their autumn hues, and **expressing** your preferences for different colours, you will not only learn more and enjoy more, but you will find the writing of your description very much easier.

Some of the things which you might pay attention to in looking at the trees in autumn are:—

1. The **order** in which the trees begin to show autumn coloration.

2. The **time** when the change begins.

3. The differences in the **time** of change in **successive years** (keep a record for comparison).

4. The change in **young** and **old** trees compared.

5. The **colours** and their mode of appearing upon the leaf in different trees.

Collecting to be done.—Collect leaves which have newly fallen, or are just about to fall from the trees. Select a number from different trees which show as many different colours as possible. Procure also a few series of leaves to show the progress of the change in each. All of you who can draw and paint should make coloured sketches of the best in your collection.

Colours Observed.—What are the various colours we usually find upon leaves in autumn? **Yellow**, **orange, red, brown.** Which is commonest? Yellow (most trees). What colours may yellow give place to? Yellow is frequently deepened to orange, *e.g.* birch, lime, horse-chestnut, rowan. The orange may further deepen to red, as one sometimes sees in rowan and horse-chestnut. So far it is an interesting coincidence that the change in these cases follows the order of the spectrum colours—green, yellow, orange, red. Orange is sometimes succeeded by brown upon a leaf, as in birch. Again, the green may give place to brown directly, as in oak and beech. But you must see these things for yourselves and record what you see.

In examining the leaves you have collected note such points as the foregoing, also describe the appearance of **individual leaves undergoing colour change.** Thus a lime leaf may appear yellow, but show a perceptible deepening to an orange tint, grading off to a light brown. Poplar leaves show a blotching of yellow and green before becoming yellow.

White beam turns yellow between the veins, thus showing bands of yellow and green, at other times the bands are yellow and brown.

Sometimes one finds in the horse-chestnut a dark green along the veins grading off into a pale green between, which in turn passes into yellow in the interspaces. Yellow and brown blotchings are common in this leaf, and sometimes a rosy pink blends with the yellow.

Write down the appearances you observe in the leaves which you examine.

Why do the leaves undergo these changes of colour? This question is not easy to answer. We cannot say that the colours as such are of direct service to the tree. They are external signs of internal processes. For they are the result of chemical changes **accompanying the temporary ceasing of the tree's activities.** We know that the **green matter** (chloroplasts) in the leaves **dissolves** and that another coloured substance is exposed (xanthophyll, yellow pigment), and that other changes involving the **formation of coloured products** may also take place.

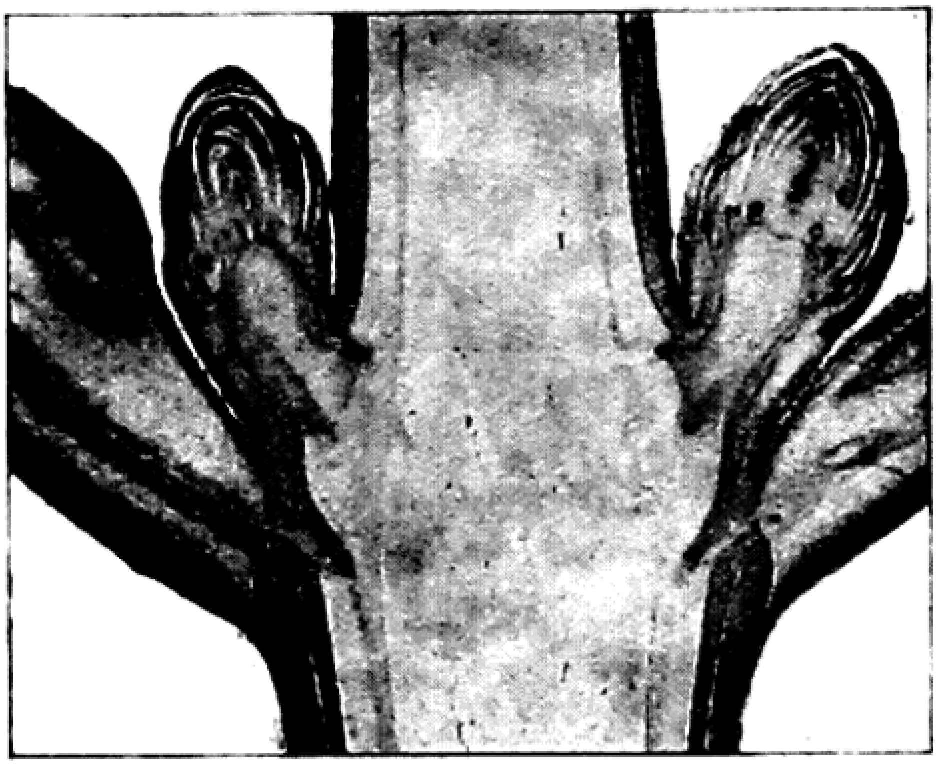

Fig. 112.—Longitudinal Section of Node of Sycamore stem, showing the Absciss layer across the base of the leaf on each side. Note the buds above the leaf bases.

Of what important process in the life of the tree are these colour changes the precursor? The **fall of the**

leaves. The two processes go together. Both are brought about by seasonal agencies, and are related to the temporary stopping of the tree's food-making activities.

How the Leaves fall.—How are the leaves separated from the parent tree? A corky layer forms across the tissue within the base of the leaf-stalk, uniting with the cork layer in the branch. This involves the closing of the passages in the veins either by constriction or by a gummy substance, so that no sap can escape. The tissue outside this corky layer in the leaf-stalk becomes broken up (the absciss-layer) so that the leaf is easily detached by the wind (Fig. 112).

Do the leaves fall off from dead branches? No. The process of cork-forming goes on only in living leaves. The leaves upon a dead branch wither with it, but they do not fall.

Do all trees shed their leaves every autumn? No; many trees do not. Such are known as evergreens. **Evergreens** are constantly shedding their leaves, but only a few at a time. Do evergreen trees show autumn changes of colour? No; as their name suggests, they are always green.

LESSON XLVII.

THE FRUITS OF TREES. (I.)

[These should be gathered as occasion offers and the pupils given preliminary exercises in the examination and drawing of specimens. Questions such as are suggested below may be asked and answered and all the points revised in the general lesson here given. A number of the fruits will be seen in the earlier parts of the year—spring and summer—and may be dealt with as they appear; the general lesson, however, is perhaps best given in autumn. As many fruits as can be found should be collected by the pupils.]

WIND-DISPERSED FRUITS.

Ever since springtime, when you found the elm fruit falling from the trees, you have noted and examined fruits of various kinds. Let us try to recall some of the facts which you have learned.

We might begin this lesson, I think, by asking a general question: **What is a fruit?** You may describe a fruit as that part of a plant which develops around the seed or seeds, and is more or less directly concerned in their dispersal.

After the pollen reaches the egg-cell of the ovule changes in the surrounding parts take place, which result in the forming of the fruit. It will help us in our study of fruits if we remember that the form assumed by these parts is related to the way in which the seeds are to be dispersed.

Most of the fruits we observe early in the year depend upon the wind for dispersal. Let us name the commoner of these.

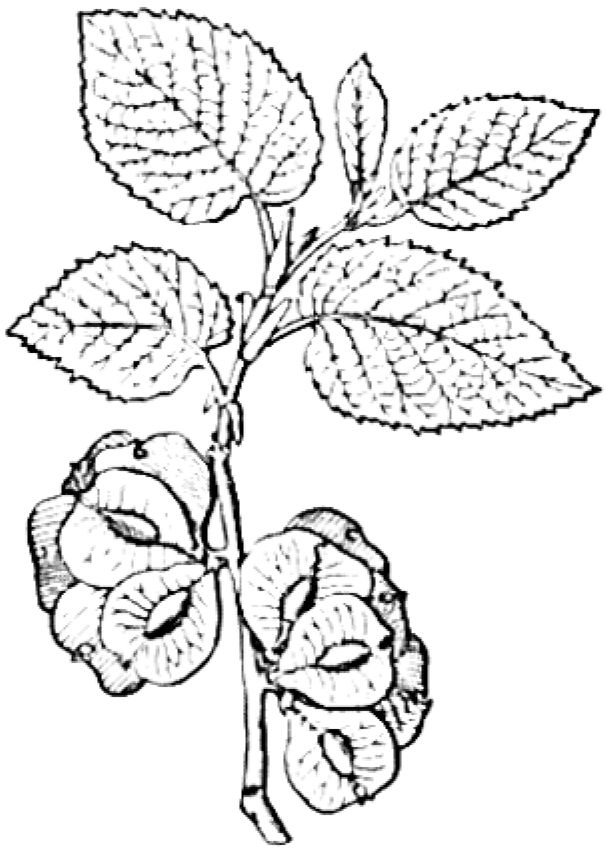

Fig. 113.—The Elm, with Clusters of Fruits.

Elm, Ash, Sycamore, Lime, Birch (Figs. 113-116).—These fruits are all simple and very similar. When ripe they each contain only one seed. The part around becomes dry and tough, or hard. They have all got a **wing-like attachment** which enables the wind to blow them some distance away from the parent tree.

What observations have you made regarding the particular way in which these parts act?

Elm.—First describe the appearance of this fruit. The "wings" extend along both sides of the fruit enclosing it in the centre. They are soft and membranous.

After the fruit falls it may be blown from place to place, and eventually be carried far from the parent tree. What is the size of a single fruit, including the "wings?"

Ash.—Describe the appearance of this fruit. What change of colour does it undergo in ripening? What is the nature of its arrangement upon the tree? What is the use of the "twist" upon it? What other use may the "wing" serve than as a parachute? It frequently acts as a **holdfast.** These fruits fall, some in summer, some in autumn, and others in winter. You may see ash trees in winter with great bunches of fruits still hanging. But after they do fall, whether in summer or any other time, they get blown about a good deal afterwards, until reaching suitable soil the "wing" may catch in the earth and hold the fruit there until the moisture and warmth of spring cause it to germinate. Remember to go in search of tree seedlings in spring, and you will be able to prove this.

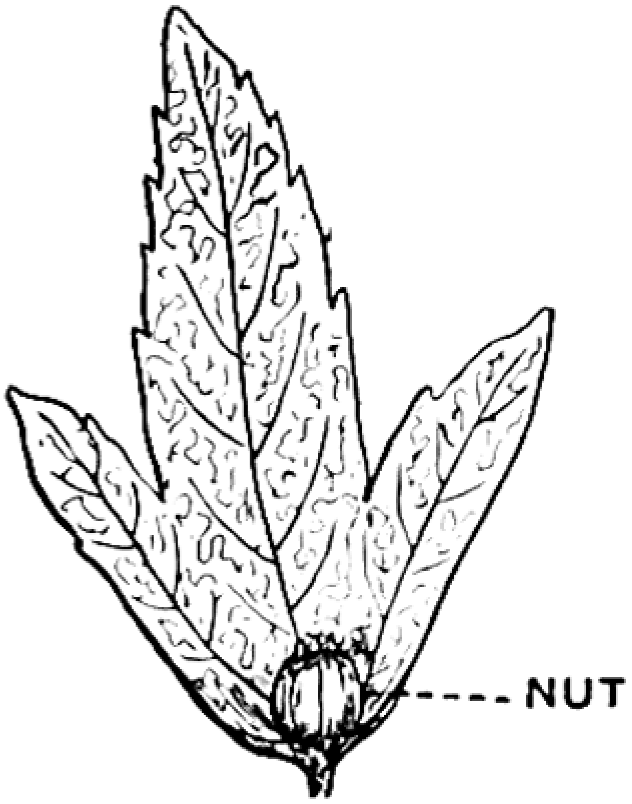

Fig. 114.—Fruit of Hornbeam.

Exercise.—Soak an ash fruit in warm water. Open it and find the seed. Split the seed open and you will **find the minute tree** with two tiny leaves between its two halves. This is, I think, the smallest tree which it is possible for you just to see with the naked eye. You will, however, see it more clearly with a hand lens. (Fig. 26.)

Sycamore.—In what particular does the fruit of this tree differ from that of both elm and ash? It is grouped upon a single stalk in pairs. The pairs separate some time after the fruit has fallen. The wing here may act in the same way as in the ash fruit.

Exercise.—Soak the sycamore fruit, open it, and carefully uncoil the young plant. Observe the long green cotyledons (seed leaves), radicle and plumule, and the absence of a separate store of food. (Fig. 25.)

Birch.—Have you seen the fruit of the birch? Which of the foregoing fruits does it most resemble in shape? The elm fruit. In what respect does it differ greatly from the elm? In size. It is very much smaller. Also the fruits are formed upon catkins, which is not the case in the elm. How are the birch fruits scattered, and when? The catkins break up upon the tree, and the winged fruits fall out and float upon the wind to the earth. They fall late in summer. It may be as late as September.

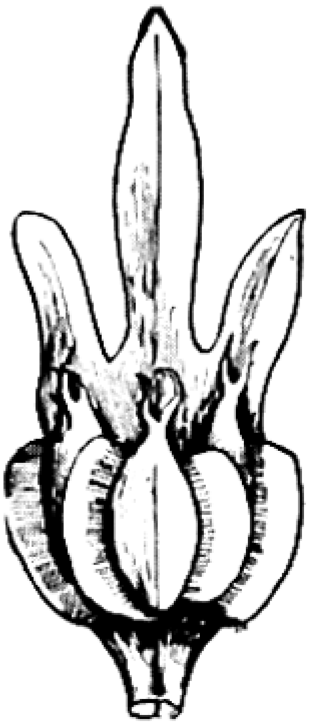

Fig. 115.—Bract of the Birch with Three Winged Achenes in its Axil.

Exercise.—Take from a birch tree some fruiting catkins which are beginning to become dry. Break one up upon a clean sheet of paper. Draw a few fruits. Besides the fruit proper and the membrane, what else do you find upon these? The withered stigmas. How many are there? Two. What else do you obtain from the breaking-up catkin besides the fruits? Small 3-lobed scales. Do you know what these are? Each scale is made up of three small leaves (bracts) which existed separately in the catkin at an earlier stage.

Draw one very clearly, and write down what it is. Notice that it remains separate from the fruit. In some cases these bracts adhere to the fruits, *e.g.* hazel, hornbeam, and oak. In the alder they remain upon the tree, becoming hard and woody, and resembling a cone. Have you seen this?

Sow some birch fruits in pots in the autumn and look out for the seedlings in spring.

The fruit of the elm, ash, sycamore, and birch is known as a **Samara**.

Lime.—Describe this fruit. What is the nature of the parachute in this case? A bract. If you know of a fruit-bearing lime tree, search for fruits in its neighbourhood in the autumn. Verify the following. The fruit stalk and bract become brittle, and may easily break away from each other, so that the bract is not so useful in scattering the seed as the "wings" are in birch, sycamore, or elm.

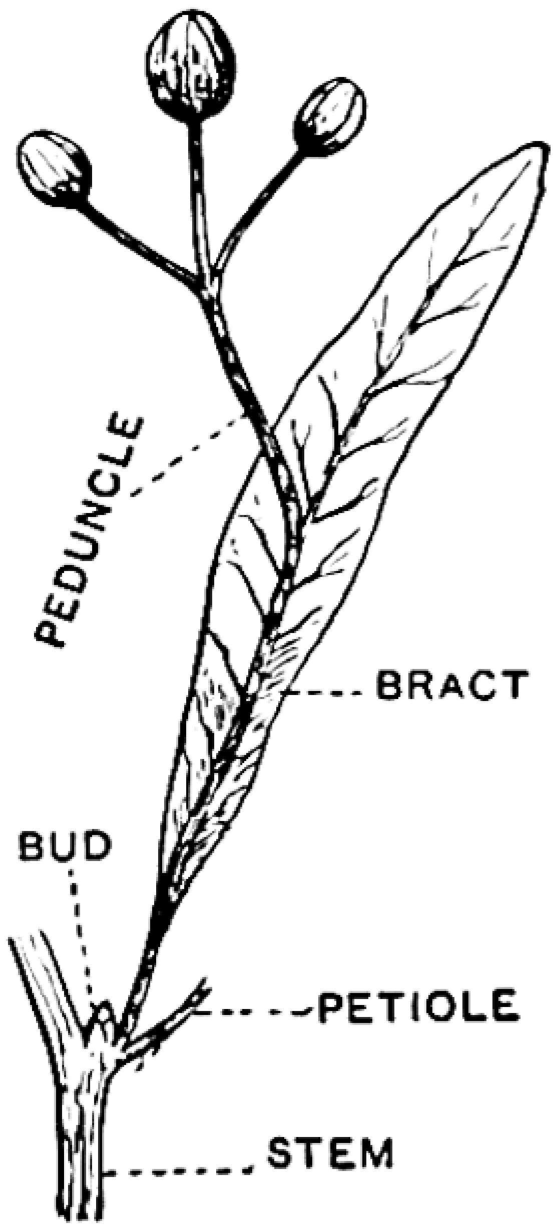

Fig. 116.—Inflorescence of Lime.

Willows and Poplars.—What has the wind to do with the fruits of these? The fruits consist of small capsules which form from the ovaries upon the female catkins. The ripe catkins fall to the ground, the capsules burst open and set free the seeds. If you know these seeds you will know how the wind acts.

Exercise.—Gather catkins of willow or poplar (in summer). Examine the seeds and note the hairy tuft at the base. The wind blows the seed about by means of it. This hairy tuft is known as an **"aril."** You may see a similar one upon the seeds of the willow-herb.

Larch, Spruce, and Pine.—What are the fruits of these? The mature cones. What part does the wind act upon? The seed; it has a "wing" at the side (see p. 365, Fig. 168).

LESSON XLVIII.

THE FRUITS OF TREES. (*II.*)

[Pupils should be asked to collect the fruits named below, or as many of them as are obtainable.]

In our last lesson we looked at some fruits of trees which were dispersed by the agency of the wind. There are some common ones which depend upon other agencies for their scattering, and these we shall now look at.

NUTS.

The nut is a common form of tree fruit. Here are some grown on trees in our own country. Hazel nuts, beech nuts, acorns (which are oak nuts), and sweet chestnuts. Before we examine them in detail let us try to put in words what are the characters of a nut. Perhaps you think it is easy to tell a "nut" when you see one. We shall see.

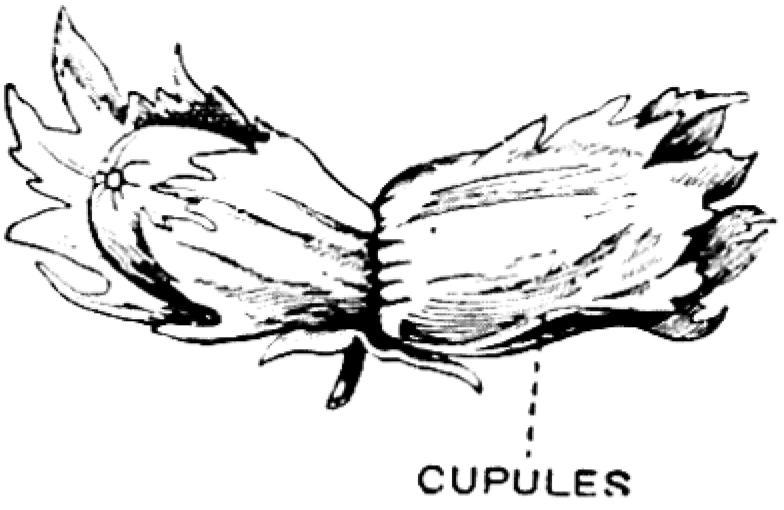

Fig. 117.—Two Hazel Nuts invested by Cupules.

Botanists describe a nut as a one-seeded fruit in which all the parts surrounding the seed (= **pericarp** or ovary) have become hard and woody, forming a kind of shell. This shell does not split open for the dispersal of the seeds, but only for germination. In speaking or thinking of a nut therefore we must remember its composition—**a hard woody shell containing a seed,** and its history—the woody shell is the altered pistil of the flower.

You should now draw each of the foregoing nuts. They illustrate one of nature's ways of providing for the future. The hard shell is really a protection for the seed against the teeth or digestive organs of animals. It is true it is not a protection against the teeth of all animals but only of some.

Now look at the **hazel nuts.** What is this **membranous leafy** part surrounding it? (Fig. 117). To answer this question we must think of the place where the nut was formed. You remember the hazel catkins which you saw in spring, not the pendulous pollen-bearing ones, but the short erect ones with the crimson stigmas. The scales or bracts of these have grown together around each developing nut, and now form this sheath or cupule. It will be interesting for you to recall the three-pointed scale of the birch fruit which we saw in last lesson, which is the same kind of thing as this "husk" upon the hazel nut. Filberts which show the same kind of thing are cultivated hazels, and the Barcelona nut of the shops is the fruit of another species of hazel.

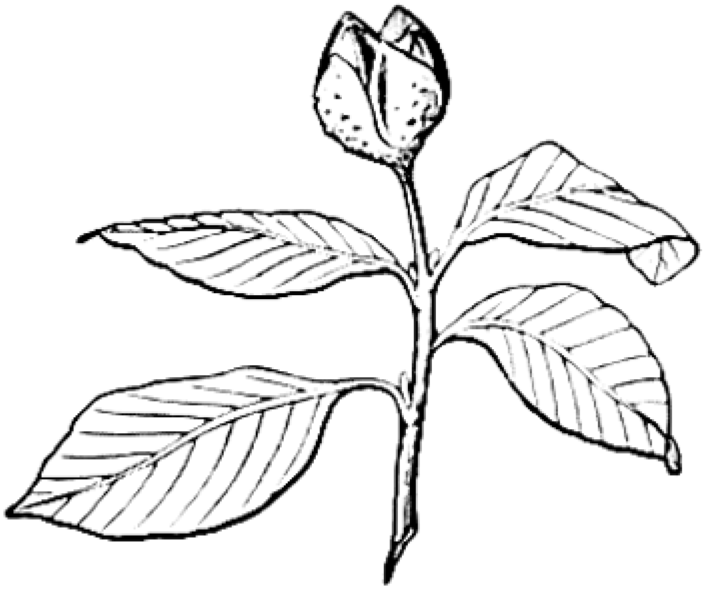

Fig. 118.—Twig of Beech with Cupule containing Nuts.

Look next at the **beech nuts.** They are enclosed within a **cupule** strong and spiny. You must examine a few and note the different stages. First the cupule which completely conceals the nuts. Then the opening cupule with slightly diverging valves. How many valves are there, and what is the shape of the cleft? Note the fine glossy inner surface of the cupule. How many nuts are there in a cupule and how are they placed? What is the shape of a beech nut? (Fig. 118.)

Name some animals which feed on beech nuts, or "beech mast" as they are termed.

Acorns.—After looking at these two kinds of nuts, you will not find the acorn difficult to understand. What is an "acorn"? An acorn is a nut of the oak surrounded by a cupule made up of a large number of bracts. These bracts are small at first surrounding the ovary, but develop along with the fruit into this cupule.

These **sweet chestnuts** are also formed within a cupule, formed from small bracts. In this case there are three nuts within a single cupule.

There are some other fruits we know which are also commonly called nuts. Here is the fruit of the **horse chestnut.** Do we really think of it as a nut? No, we may call it a chestnut as everybody else does, but we can see it is a different kind of thing from a true nut.

First of all, make a sketch of a complete horse-chestnut fruit. Note its globular shape, its colour, and its prickly outside. Is this fruit hard and woody? No, it is tough and thick walled but not woody. Does it open to permit of the scattering of the seeds? Yes. Into how many parts does it split? Into three parts. Does it contain only one seed? There are generally traces of three seeds, but one is usually much larger than the others. So you see this is a different thing from a nut (Fig. 119).

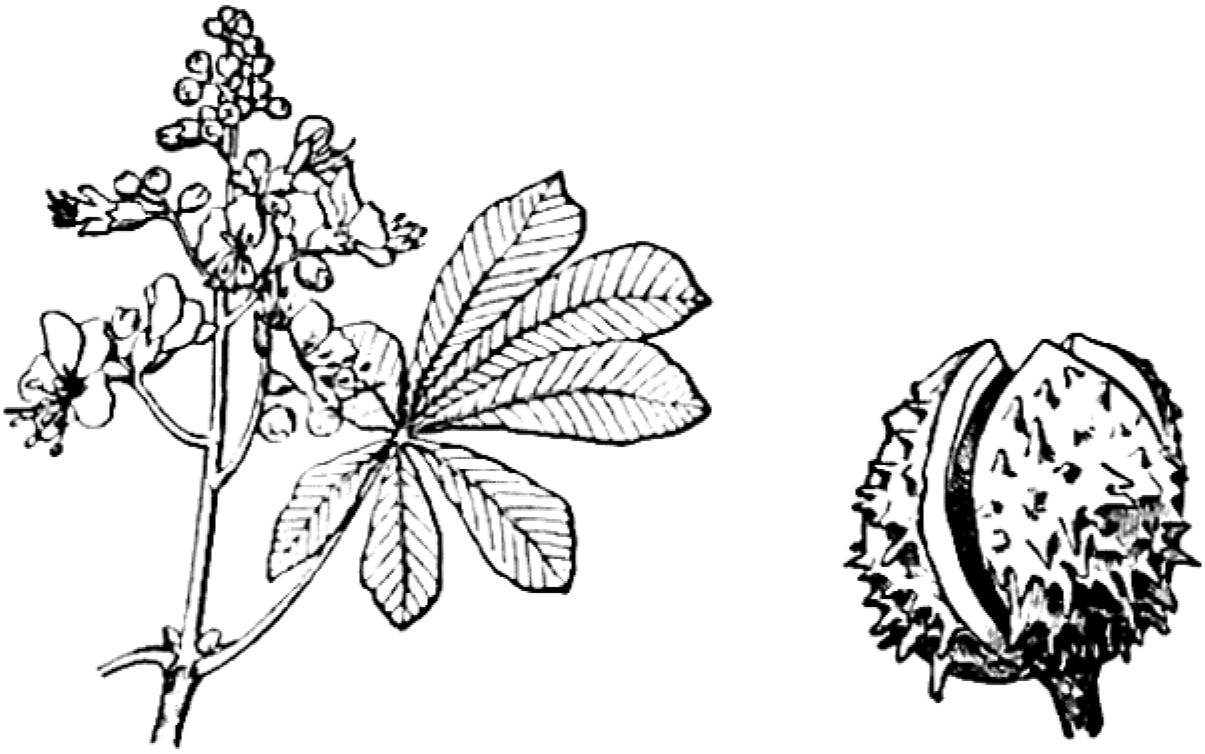

Fig. 119.—The Horse-Chestnut—Leaf, Flowers, and Fruit.

What do we call this kind of fruit? It most closely resembles the fruit known as a **capsule,** which is formed from an ovary made up of a group of united carpels (syncarpous ovary), becomes dry when ripe, and opens for the scattering of the seeds. Many flowering plants have capsular fruits. The fruit of the wallflower is one kind of capsule (a siliqua), that of the chickweed, stitchwort or campions is another, poppy fruit is another type, and so on.

Remove a **seed** from a horse chestnut fruit. Soak it in water overnight. Then remove the seed coat and examine the contents. Identify the following parts: the two fleshy seed leaves (cotyledons), the embryonic root (radicle), stem (plumule), and beginnings of the first pair of true leaves. Note the indications of leaflets in these.

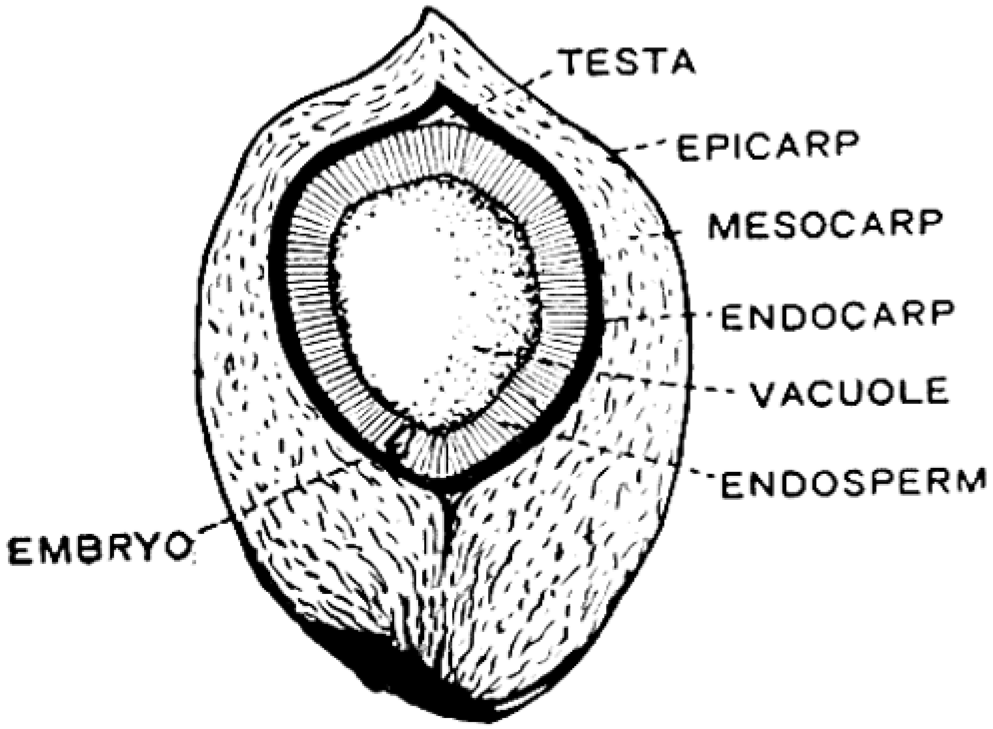

Fig. 120.—Coco-nut Drupe, cut to show its various layers.

Before leaving the subject of nuts, notice some other examples of "nuts," which are not true nuts. The **brazil nut** is really a seed with a woody coat from a capsule of a South American tree (*Bertholletia excelsa*). The **walnut** is really a stone fruit, the shell being only the innermost layer of the ovary (endocarp). So also is the **coco-nut.** The white flesh with its brownish skin and enclosed "milk" together with a minute seed plant embedded in the flesh is the seed; the "shell" is the endocarp, outside of which in the complete fruit is a fibrous layer (mesocarp) enclosed by a tough skin (epicarp) (Fig. 120).

FRUITS ATTRACTIVE TO ANIMALS.

A very familiar type of fruit upon our trees is one which by its colour is so conspicuous as to attract attention. Such fruits are not only pleasing to the eye, but also are more or less juicy, and usually sweet to the taste. These qualities make them much sought after by animals, who in different ways scatter the contained seeds. How many such fruits can you name from trees growing in our own country? Apples, pears, cherries, geans, rowans, hawthorn ("haws"), rose hips; these are among the commonest; but there are many others. The actual structure of these fruits is not the same in every case, and for the present we need not consider them from that point of view. We know that in each case besides the juicy or edible part of these fruits, there are the seeds and in some some instances inedible parts surrounding them. Let us see the means for dispersal in each.

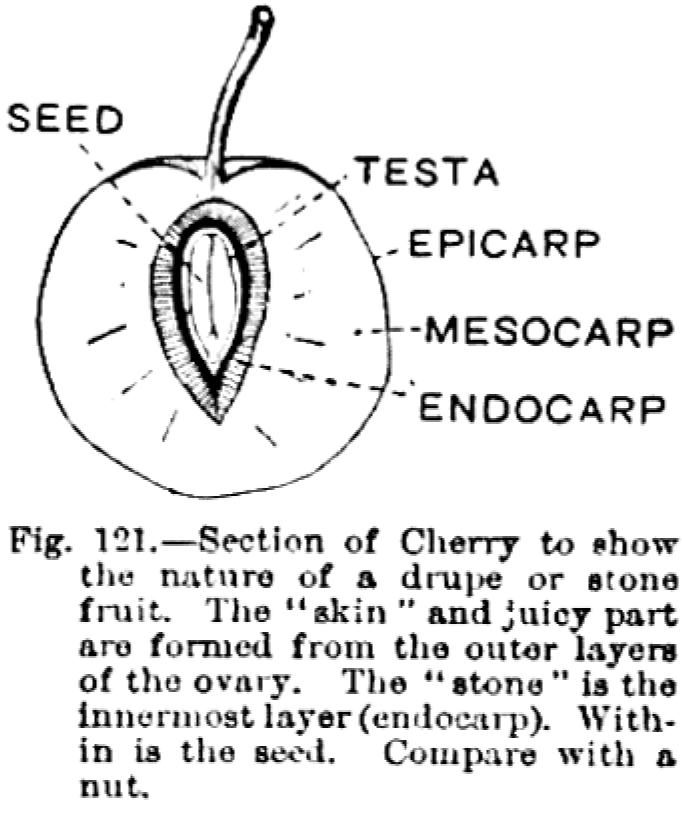

Fig. 121.—Section of Cherry to show the nature of a drupe or stone fruit. The "skin" and juicy part are formed from the outer layers of the ovary. The "stone" is the innermost layer (endocarp). Within is the seed. Compare with a nut.

Apples and Pears.—There is an inedible "core" enclosing the seeds. In wild nature the animals which deal with these drop the core and seeds. If these should drop in suitable ground they have a chance of germinating.

Rowans, Hawthorn, Rose-hips.—These are pecked at by birds. The softer parts are eaten and the seeds dropped. Sometimes seeds, if protected by a hard covering, may pass through the bodies of birds uninjured. The seeds in the hawthorn are surrounded by the carpels, which are very hard.

Cherries and similar fruits have the seed contained in the so-called " stone," which is formed from the innermost wall of the ovary. These fruits are pecked at by birds and the "stone" dropped. But even should the stone be swallowed by animals, it passes unharmed through their bodies. If it fall in suitable ground in course of time it opens and permits the seed to germinate (Fig. 121).

Apples, pears, rowans, " haws," are known as **pomes.**

Cherries, plums, and similar stone fruits are termed **drupes.**

Individual lessons upon particular fruits should also be framed. A series of such may very suitably be given first, and the facts brought out in the foregoing subsequently framed as revision or summary lessons.

OUTLINE LESSON UPON A PARTICULAR FRUIT,

e.g. **Apple.**

Supply an apple for examination to each pair of pupils, or if the quantity of fruit available is limited, engage one of the best pupils to assist in passing the lesson specimens around the class when necessary, and to demonstrate the points raised in the course of study. For lesson specimens select well-coloured examples which show clearly the five rounded elevations upon the top, next to the withered remains of the flower.

1. Comment upon the attractive appearance, odour, and taste of apples. Ask questions to bring out significance of these in distribution of seeds.

2. Draw the apple upon the blackboard so as to exhibit the top clearly as well as other parts, *e.g.* the stalk. Make pupils also draw the specimen. All special points included in the teacher's drawing to be shown upon the specimen to the pupils.

3. Question as to the relation of the fruit to the flower, eliciting its position below the calyx, etc. Enquire as to the meaning of the five "lumps" more or less clearly seen on most apples. Explain relation of the carpels to the hollow fleshy receptacle, and the share of both in the making of the fruit. Compare other fruits similarly formed, *e.g.* Rowan Pear, etc.

4. Cut the apple across the equator. Teacher and pupils will make a drawing of the exposed surface. A drawing of a young ovary in section may also be made for comparison.

5. Interpret *along with pupils* the parts exposed—juicy receptacle, leathery carpel walls—seeds. Question as to the number of carpels making up the ovary (Fig. 122).

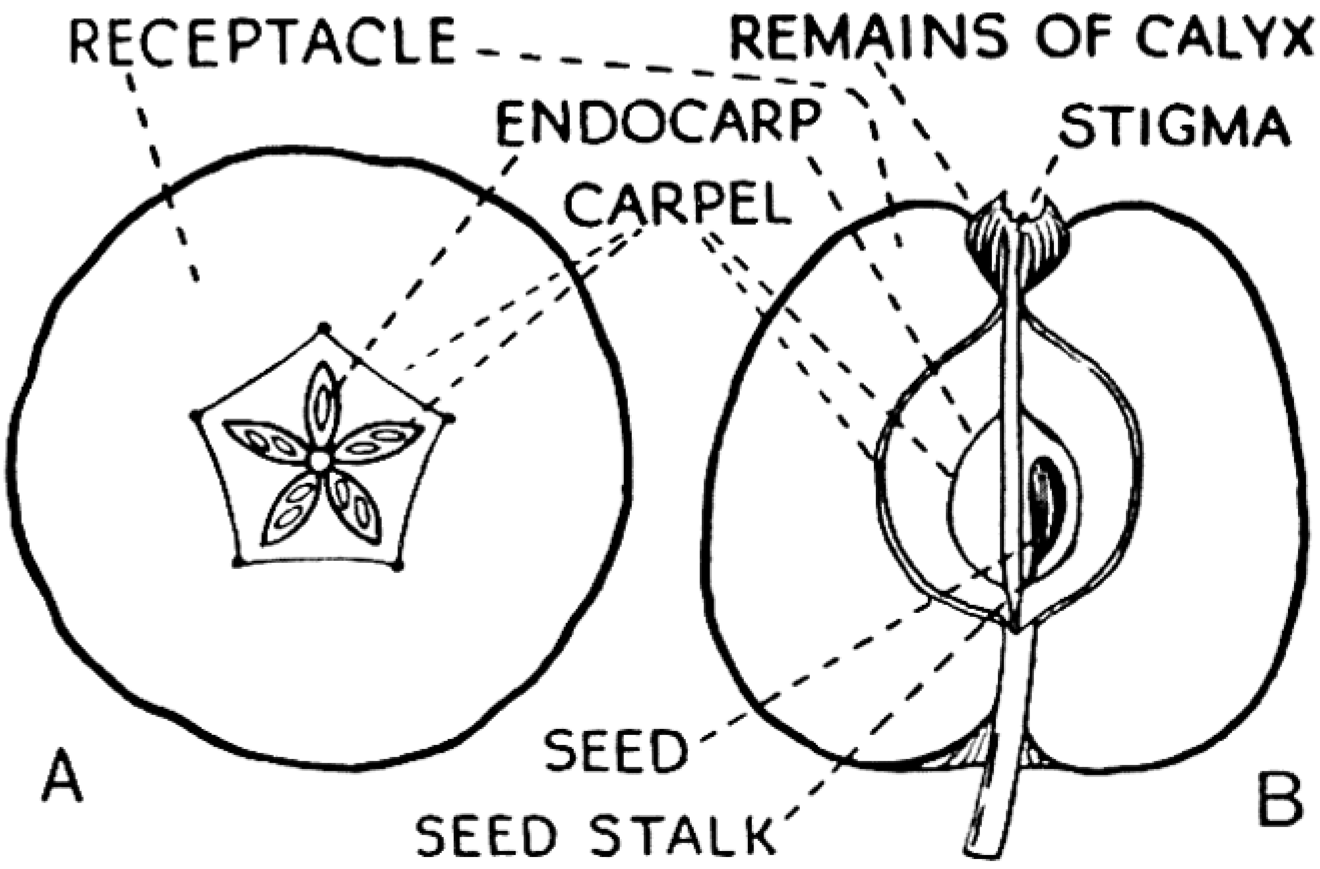

Fig. 122.—(A) Young Ovary cut transversely; (B) Fruit of Apple cut vertically.

LESSON XLIX.

FERNS.

[Ferns are suitable objects to grow in school. The decorative value of well-tended ferns is very great.

For this lesson the teacher should have a few fronds of various ferns, *e.g.* male fern, bracken, hard fern, hart's tongue, maidenhair, polypody, as many as possible bearing spore clusters, also an underground stem of *e.g.* male fern and one or two others. As a development of the lesson, by way of maintaining continued interest, the teacher should endeavour to grow fern prothalli. As far as the specimens available admit of it, the first lesson may suitably follow the line of tracing various grades of complexity of the frond. Fern fronds may conveniently be obtained from Nurseries.]

The Hart's Tongue Fern.—Here is a familar fern, grown abundantly indoors because of its beauty and freshness. It is also well known in various places, growing out of doors in well shaded and moderately moist places. It is not difficult for us to see why it is called by this particular name. The frond or leaf is long and narrow, not unlike what we would expect the shape of a hart's tongue to be.

Make a drawing of a complete frond. Notice as you do so the gentle tapering form, the not too sharply pointed tip, the slightly curved broad end, and the stalk. Other things you will observe as you examine the frond and which you should try to represent in your drawing are the backward curving, the irregular wavy wrinkling of the margins, and the brownish scaly coating of the stalk.

What part of the fern plant is the **frond?** A leaf. That is so. If you have a complete plant and trace it downward, where does it go? Below the ground. That is, it arises from an underground part. If you trace the fronds of any of our native ferns, you will find that they all arise in the same way. Since the fronds are really of the same nature as leaves, and they arise from beneath the ground, you will understand where the stem is.

The stem, or **rhizome** as it is called, with its roots, is below the ground. We shall consider it more fully in another example.

As you draw the frond, hold it up to the light. Do you see the **veins?** How do they run?

Do they form a network? No. Compare the fronds of other ferns with regard to this. Do you ever find them forming a network? No. This is a peculiarity of ferns.

Be sure that in your drawing you include a view of the back of a frond. On many of these you find brown masses. How are they arranged? In rather long lines. How do they lie with regard to the veins?

What are these brown masses? These are the clusters **(sori)** of bodies **(sporangia)** containing the **spores**. What are these spores? They are the bodies which give rise to new fern plants. You should examine a cluster (sorus) with a lens, noting the projecting ledge or wall around it.

The Hard Fern.—Take now a frond of the **hard fern.** What is the most noticeable difference? The frond in the hard fern is divided into a large number of small lobes. These lobes are known as **pinnae.** Make a drawing of this frond also, so that it may be compared with that of the hart's tongue. Note that in the hard fern there are some fronds which bear spores, and that there are others which do not. Make observations on any difference in the appearance of the two kinds, and note particularly where the spore clusters are placed, viz. **along the margins of the pinnae.**

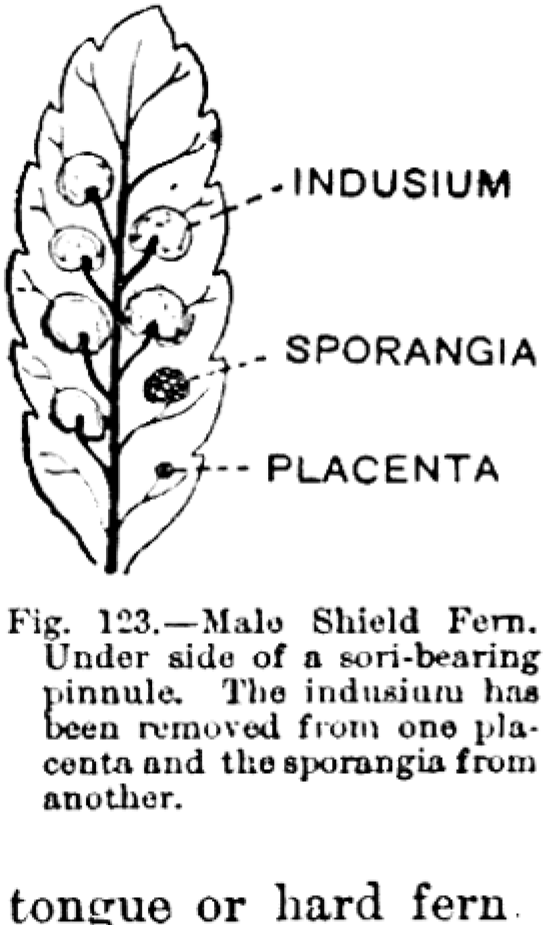

Fig. 123.—Male Shield Fern. Under side of a sori-bearing pinnule. The indusium has been removed from one placenta and the sporangia from another.

Male Fern.—A suitable fern frond to look at next is that of the **male fern.** First of all you see it is much broader and, when fully grown, also very much larger and has more parts. Its various parts, however, are not difficult to understand. The stout stalk which rises out of the ground is the same part as we have seen bearing the frond in the hart's tongue or hard fern. From this stalk pinnae arise, but these are mostly less simple than we have seen. Commencing at the base of the frond, we notice that each pinna shows in a general way the features of the entire frond of the hard fern, being in turn divided up the same way. The lobes of these pinnae are known as **pinnules.** As we pass up towards the tip, notice the regular shortening of the pinnae, and their gradual change to a simpler form.

You must examine fronds in which the **spore clusters** have formed (Figs. 123-5).

Notice the special characters of these. They are in small masses arranged in rows upon the backs of the pinnules. At first they are covered by a whitish **membrane** (indusium), which has a close coiled form, generally described as kidney shaped.

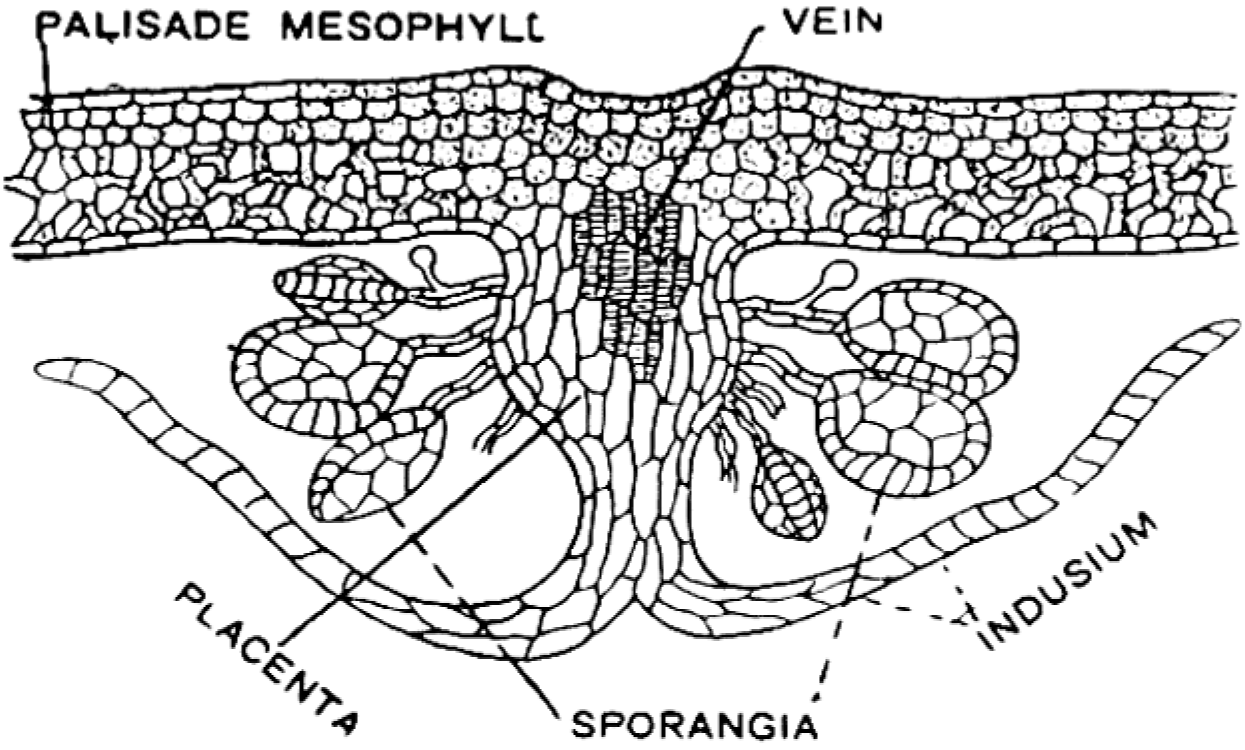

Fig. 124.—Male Shield Fern. Section through a pinnule with its sorus below. Note the relations of the various parts.

The best way in which to compare these fronds is to make a third drawing alongside the other two, and to make a companion series showing the different arrangement of the spore clusters in each case.

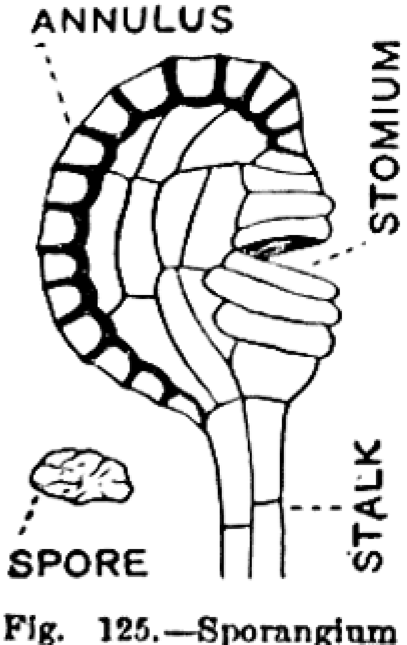

Fig. 125.—Sporangium and Spore of a Fern.

Bracken Fern.—The frond of the **bracken fern** might now be examined and compared with these. It is more complex still, but if you proceed to examine it from below, you will not find it difficult to make out the parts in relation to the simpler forms. From the main stalk are given off toward the base secondary stalks which may be compared with the entire frond in the case of the male fern. They tend to bend inward rather than lie flat, and as we proceed towards the tip gradually assume a simpler form. Notice, too, the arrangement of the spore clusters. What fern that we have examined shows the same arrangement, viz. around the margins? The hard fern (Fig. 126).

Try to complete your series of drawings by including the bracken, showing in this case also the spore cluster arrangement.

Experimental Work.—If you can find a frond of male fern or bracken which shows these spore clusters well developed, you should perform the experiment already suggested (p. 257). You should also each make a series of preparations of fern fronds by pressing them between folds of suitable paper. Afterwards, when they are quite dry, fasten by means of neatly cut gummed slips to clean white paper, and write down the name of each, together with any other particulars your teacher may suggest. These might form part of a general collection of flowers, leaves, etc., similarly prepared.

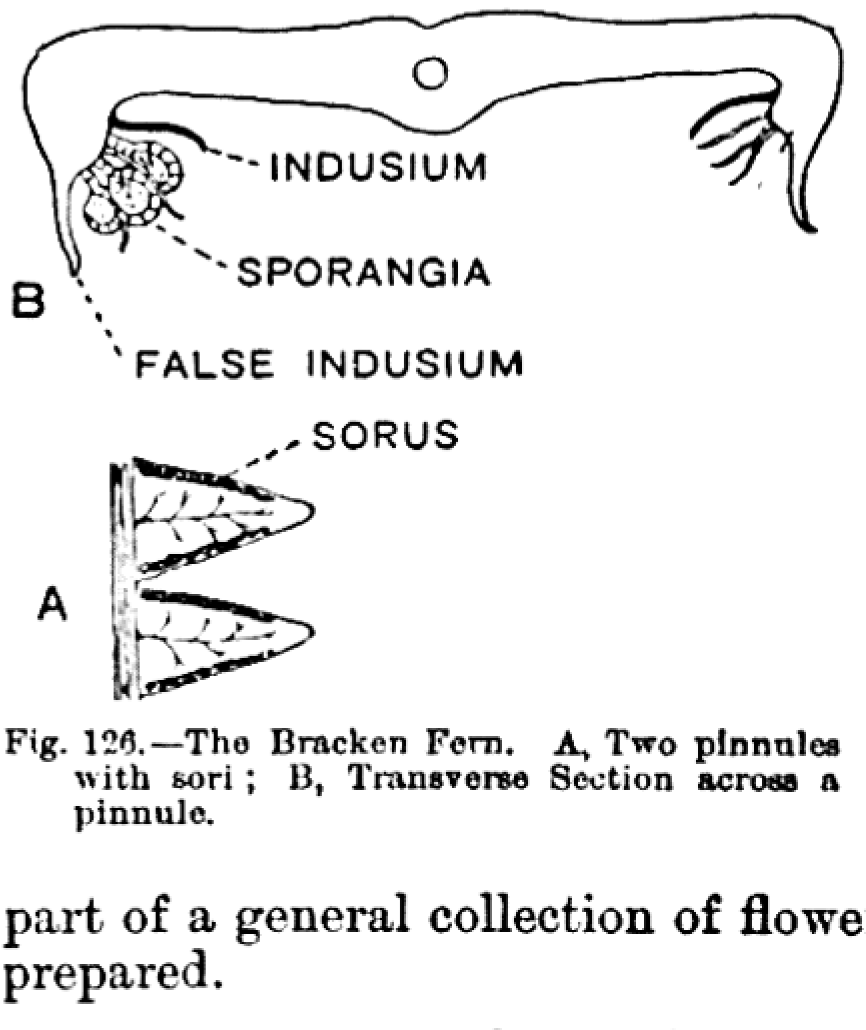

Fig. 126.—The Bracken Fern. A, Two pinnules with sori; B, Transverse Section across a pinnule.

Be sure to note the small size of the spores, compared with which an individual spore cluster is enormously large. They are just visible individually to the naked eye, although a lens will help you to see them more clearly. Do not fail to observe and to think of the greatness of their numbers—each one capable of yielding a fern plant—remembering how few are likely in nature to do so (p. 257).

In spring, sow plentifully spores gathered as suggested upon the surface of moist pieces of tile or brick. Keep damp, but do not put water on directly. Cover with a bell jar and keep moderately warm. In due course you may expect to find a number of young ferns (see below).

Underground Parts.—Having examined a series of fronds, we may now make a brief study of the underground parts. If you have dug up the rhizome of the male fern, note the thickly clustered and withered bases of the fronds. The following exercises may suitably be performed.

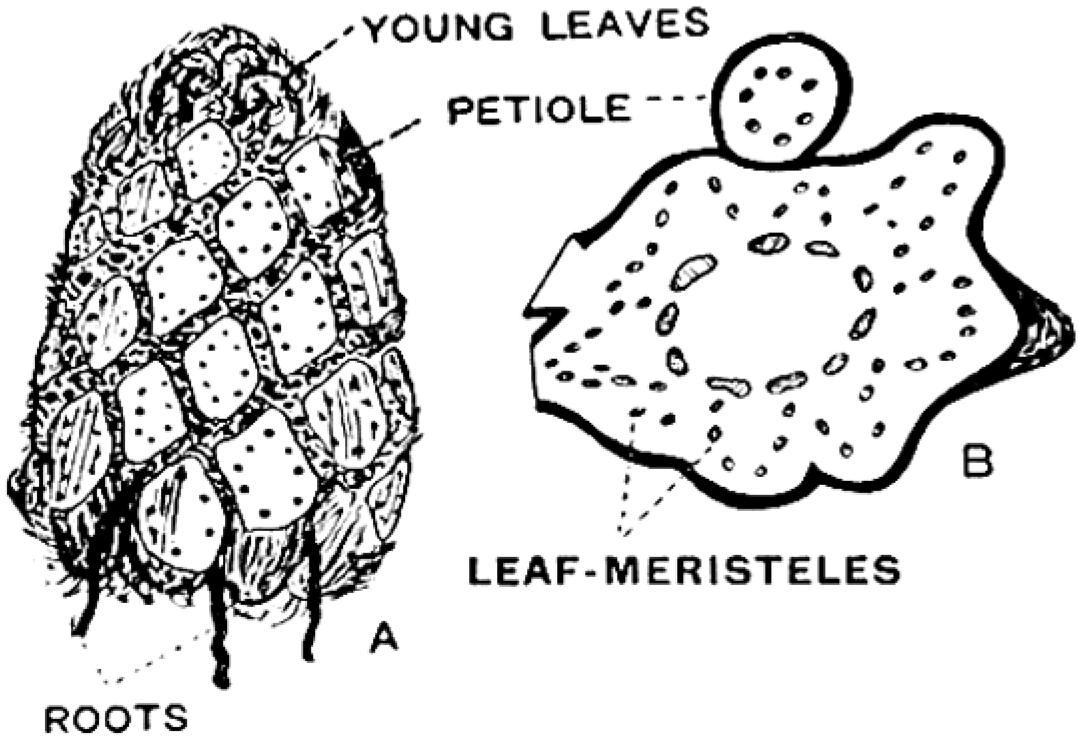

Fig. 127.—Rhizome of Male Shield Fern. A, upper part, from which the older leaves have been cut off at the base and most of the roots removed; B, a diagrammatic traverse section.

With a sharp knife cut the rhizome in two. Identify upon the cut surface the following:—Leaf bases, conducting strands of leaves and of rhizome, general packing tissue (Fig. 127).

Place a piece of rhizome in water and allow it to macerate for a time. Examine frequently, brushing away the softer parts until the meshwork of conducting bundles is left clean. Allow it to dry. Make a sketch of it, marking the central lattice work of stem conducting tissue and the smaller bundles of the fronds. Mark also the spaces occupied by the frond bases (Fig. 128).

From the germinating spores small green, flat, heart-shaped bodies arise. When grown, these should be examined with a lens. The particular interest of these bodies (**fern prothalli**) is that

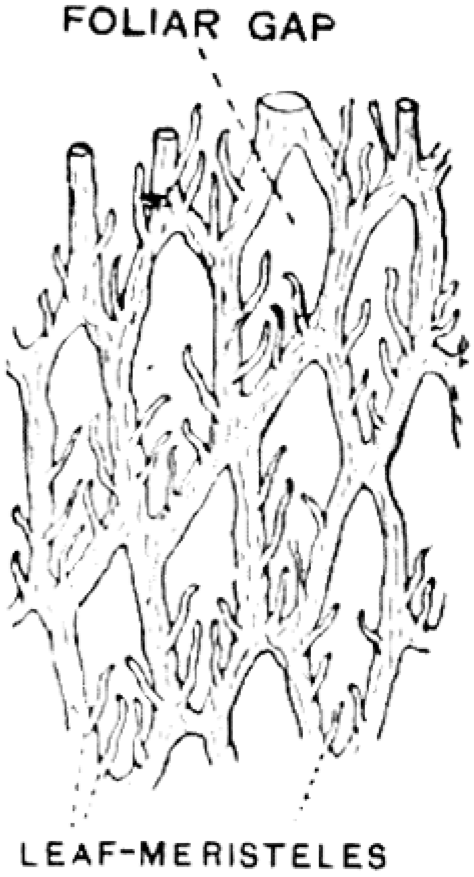

Fig. 128.—Part of the Vascular System of a Fern dissected out.

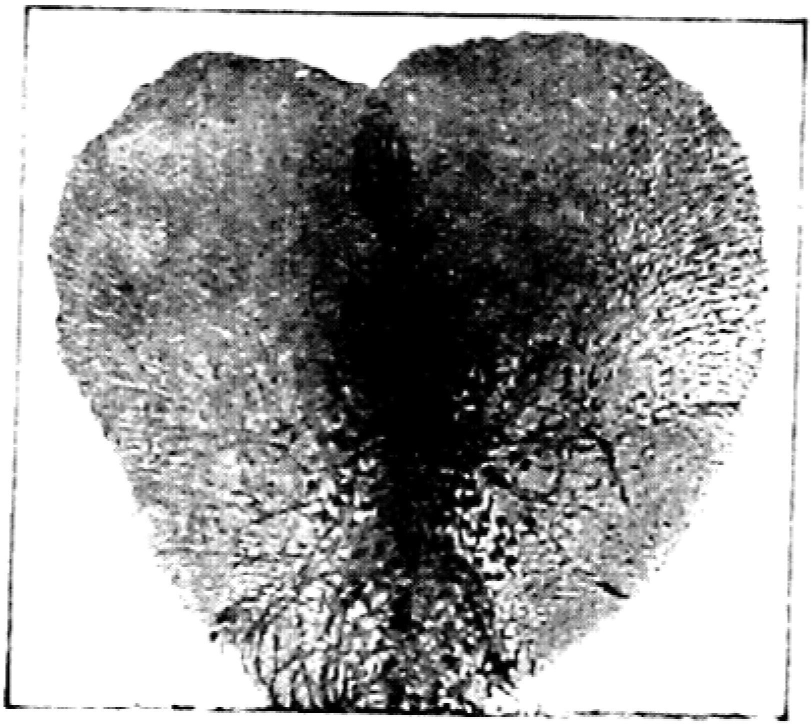

Fig. 129.—Prothallus of Fern (under side).

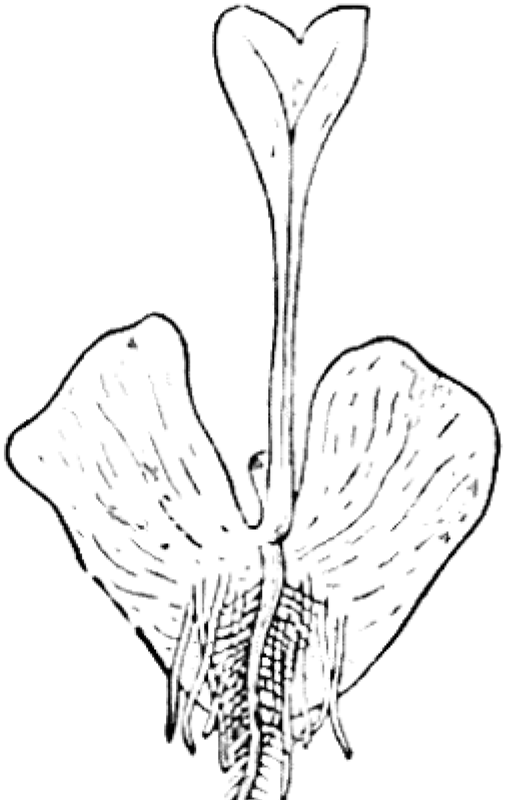

Fig. 130.—Young Fern still attached to the Prothallus, growing from an archegonium.

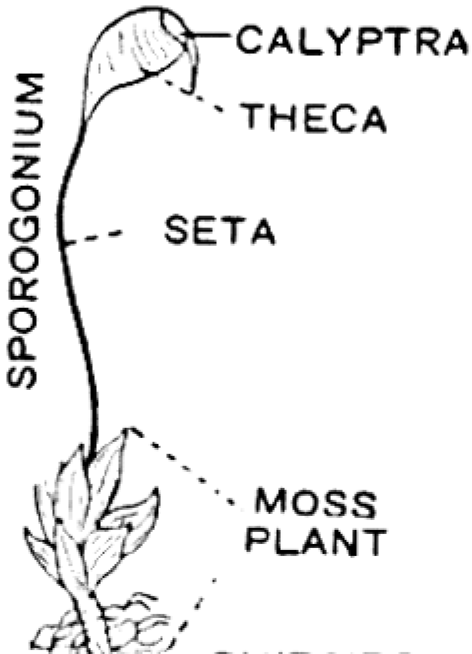

Fig. 131.—Funaria, a common Moss. Both generations are represented. The sporogonium is the spore-bearing generation. Spores are formed in theca.

they do not give rise to ferns directly, but produce upon their under sides organs yielding sexual bodies upon the union of which depends the arising of the leafy fern. There are thus two generations in the life-history of the fern, viz.

Spore producing Prothallus (Sexual) ...... = Generation I.
Fertilised Archegonium Cell (Sexual Body borne by Prothallus) giving rise to leafy fern, which in turn produces Spores...... } ,, II.

This is known as **Alternation of Generations** (Figs. 129, 130).

The teacher might profitably compare the two generations in the Fern with those in a Moss. In this latter case the two generations can be demonstrated without difficulty. See Fig. 131.

LESSON L.

A COMMON SEA-WEED (*Fucus*).

[For schools situated near the seashore a study of sea-weeds is both suggestive and interesting. It is not without value even in schools inland if the materials can conveniently be obtained. One of the commonest weeds on the seashore is the one about to be considered. Although it is not amongst the most attractive-looking, it is large, and exhibits the essential characters of thalloid plants very clearly. In addition to the present study, collecting and mounting the smaller and more pleasing forms, especially of the red sea-weeds, may be practised.]

Habitat and Habit.—On most coasts with rocky shores this fucus weed abounds between tide marks. Probably most of you have seen it. In places where it occurs can you say whether it grows abundantly or not? It grows abundantly. That is one of the things which strike us. Great tracts of rock usually lie completely buried beneath its **dark coloured slippery fronds.** There is a very noticeable feature about the habit of growth of this plant in which it differs markedly from land plants of the same size. All who have seen it growing when the tide is back notice this. What is it? It lies **prostrate.** Large though these plants are, without the support of the water they cannot stand erect.

What is the colour of this plant? It is a dark **brown** colour. A simple and useful way of grouping sea-weeds is as brown, green, or red. Where sea-weeds grow you will not have much difficulty in finding examples of each of these three kinds. The fucus is one of the commonest of the brown sea-weeds.

The Parts of a Sea-weed.—Now let us look at an entire plant. I shall spread it out that you may see its general form. There are several kinds (species), but meantime we need not heed the differences between these. This one is known as the **serrated** wrack. Notice the saw-like edge of the fronds from which this name is taken. What is the use of this flattened part at the lower end of the plant? What does the sea-weed do with this? It **grasps the rock.** If you have ever tried to pull off an entire plant from the rock you have found that it grips well. And remember also how these have to withstand the tearing action of the waves at all seasons.

Is this the root? Most of you think so. Do you remember the work which a true root performs? It holds the plant in the ground, and also absorbs substances from the soil which go to nourish and build up the body of the plant. The latter is the more important use of a root, and this portion of the sea-weed we are looking at does not do this. Nor has it got the structure which a true root has. It is therefore not really a root. We call it a grasping organ or **holdfast.**

Above the holdfast there is a short rounded stem-like portion, the **stalk.** Above this the parts are flattened, dotted all over, and notched along the edge, and in the plant we are looking at you observe a central thickening like a midrib. The more carefully we look at the parts we find it difficult to describe them as stem and leaves. A sea-weed is really a much simpler plant than one with root, stem, and leaves. It is simpler than a fern or moss, and its parts, though in a general way they **resemble** these organs, are not made up similarly. Nor can the work of stem and leaf be distinguished as separate in this plant.

` To distinguish all these parts the name of **thallus** is employed, not root, stem, and leaves.

Mode of Branching.—Let us look at the **branching** of this thallus. Starting near the base, observe how it **forks** in two. Follow a branch, *e.g.* the left, a little way up, it also divides in two, follow either of these and again a division in two. Take every branch of the thallus and trace it upward and you find it divides in two.

This shows us how the sea-weed grows, by the lengthening and regular dividing of the branches.

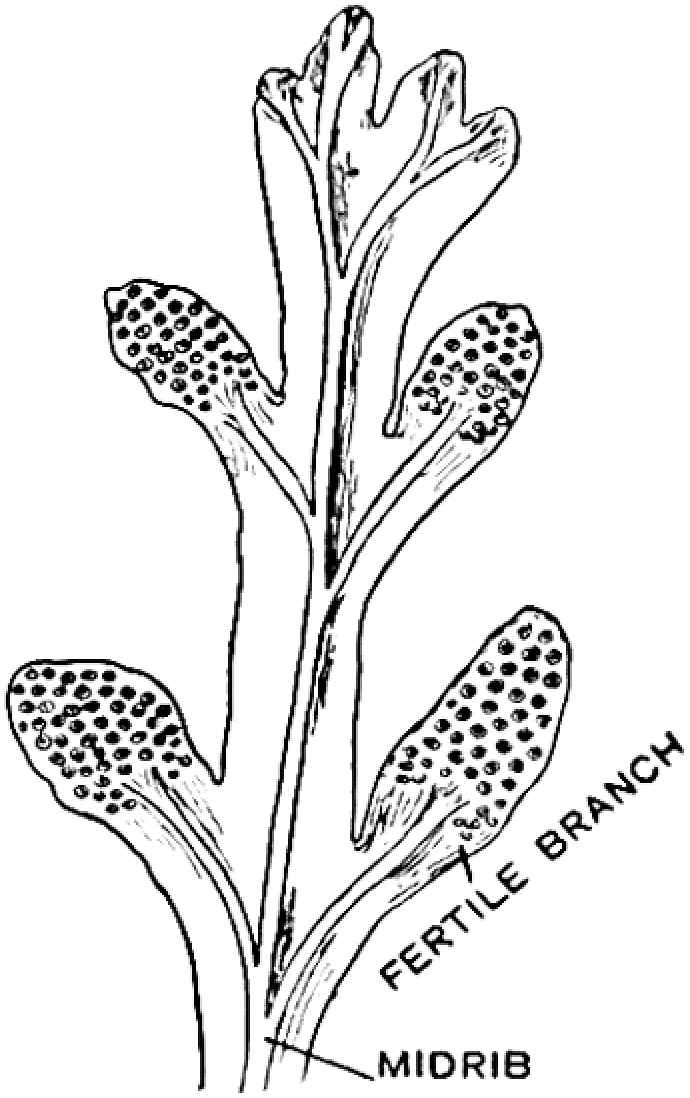

Fig. 132.—Tip of a branch of Fucus.

Origin of New Plants.—How do new fucus plants arise? Examine the thallus of this weed once more. Do you notice any parts which we have not yet looked at? You discover that certain branches bear tips which are swollen, are rather pulpy to the feel, and are covered with small warty-like points. These warty-like points have an opening leading into cavities in which bodies having the same function as ovules and pollen cells are formed. It is from these, after passing out into the water, that new plants arise. These warty, bladder-like parts, then, may be described as **reproductive,** since they produce new plants. (Fig. 132.)

Different Species.—On the shore where these plants grow one can frequently obtain several different kinds. Here are four common kinds for you to examine. You should look for them on the shore; sometimes they can all be found in the same region. You will find it an interesting exercise to compare them, noting in what they agree and in what they differ.

A. FLAT THALLUS WITH MIDRIB-LIKE THICKENING.

1. **Serrated Wrack** (*Fucus serratus*).—With notched or toothed edges and dotted all over with minute points.

2. **Bladder Wrack** (*Fucus vesiculosus*).—This form has bladder-like swellings in pairs containing air upon the thallus. The reproductive swellings are in pairs and often forked. The bladders serve to float up the weed in the sea.

B. THALLUS WITHOUT MIDRIB-LIKE THICKENING.

3. **Knobbed Wrack** (*Fucus nodosus*).—With air-bladders.

4. **Channelled Wrack** (*Fucus canaliculatus*).—With thallus folded, forming a groove or channel. Occurs near high-water mark.

Exercise.—Make a drawing of a portion of the serrated weed to show

(*a*) the shape of the frond, with its distinctive edge, dots, and midrib;
(*b*) the characteristic forking of these weeds;
(*c*) the reproductive swellings, with their dots (Fig. 132).

In another drawing show the holdfast.

Recall the weed upon the seashore. It grows in a region which is alternately covered by the sea and is exposed to sun, air, rain, and frost. It is a hardy type of plant, for in spite of these things we see it spreads abundantly. Its gelatinous structure within saves it from drying when exposed to the heat and air, and being prostrate really is an advantage, for, as you can see, the fronds lie in great masses, the under ones covered and kept wet between the tides. Were these weeds erect they could not stand the drying action of air and sun nearly so well.

The Animals Living on the Weed.—You should search these weeds for animals which live amongst them. Many **molluscs** may be found crawling and feeding upon the fronds. A very pretty one is known as the **pellucid limpet,** from its thin translucent shell. We often find a little limy coil in great abundance attached to the weed. This is the home of a small worm called **spirorbis.**

Sometimes one gets delicate net-like crusts growing attached to them. These are colonies of animals belonging to a group known as **Polyzoa.** Various horny corals of a simple type (Hydrozoa) are common, attached here also. These are sometimes also termed sea-firs.

Crustacea known as Amphipods abound, sheltering and feeding upon the debris which gathers amongst the fronds.

The fucus, you see, harbours a variety of living things in the thickets of its branches.

GENERAL CHARACTERS OF THE NATURAL ORDERS

of the Flowering Plants (other than Trees) studied in the foregoing Chapter.

(For explanation of botanical terms see Glossary.)

CAMPANULACEAE.—Flowers with petals united in a tube, five-partite, epigynous; the calyx lobes united, tips free, persisting around the fruit; stamens 5; carpels 2-5, united. The fruit a capsule, opening by valves or pores. Leaves simple, alternate, without stipules. Herbs mostly. *Campanula sp.*, **harebell,** etc., **lobelia,** are examples.

CAPRIFOLICACEAE.—Calyx and corolla both with parts united, parts usually five, epigynous; stamens 5, epipetalous; carpels 2-5 united, ovary many-chambered, fruit a berry or a drupe.

Mostly shrubs, with opposite, decussate leaves.

Examples:—

Lonicera periclymenum—**honeysuckle.**
Sambucus niger—**elder.**
Viburnum opulus—**guelder rose.**

RANUNCULACEAE.—See p. 57.

Aconitum napellus—**monkshood** or **wolf's bane.**

QUESTIONS ON CHAPTER V.

(AUTUMN: PLANT STUDIES.)

1. In a harebell flower are the stamens or stigmas ripe the sooner? What happens if insect-pollination fails?

2. How are the seeds of the hare-bell scattered?

3. What is the nature of the hood in the monkshood flower? Describe the nectary of this plant.

4. Explain how humble bees serve to pollinate the monkshood. Which mature the sooner, stamens or stigmas?

5. What relation exists between the distribution over the globe of monkshood plants and humble bees?

6. Enumerate four characteristic features of the honeysuckle plant.

7. Some honeysuckle plants appear white in the inside, others yellow. What is the meaning of this difference?

8. There are two stages in the opened honeysuckle flower—a male and a female. Which comes earlier? What kind of insect pollinates this plant, at what time do its visits occur, and how does the insect first find the flowers?

9. Describe the honeysuckle fruit.

10. Name a dozen wild fruits, and explain the mode of distribution in three instances.

11. Describe the autumn appearance of the leaves of the following trees:—lime, horse-chestnut, beech, oak, rowan.

12. Describe the general appearance of the fruit of the ash tree, and explain the use of the various parts.

13. What parts are present in a ripe fruiting catkin of the birch? Compare the fruit of the birch with that of the hazel.

14. Make a drawing of the fruit of the lime with its attachments.

15. How are willow seeds dispersed? Describe the seeds of the pine and state the mode of their dispersal.

16. What is a nut? Give some examples of so-called nuts which are not true nuts.

17. What is the nature of the "husk" of the hazel nut, the cupule of the beech nut, and of the acorn?

18. Name six fruits whose seeds are dispersed by animals.

19. What is a "drupe"? What is contained within the stone of a cherry?

20. Describe the fruit of the horse-chestnut.

21. Compare a frond of the hard fern with that of the bracken. What difference is there in the position and form of the spore clusters in hart's tongue, bracken, and male ferns?

22. What is a fern frond? Where is the stem of the male fern situated?

23. What is the nature of a fern spore? What does it give rise to in the first instance?

24. Name some differences in structure as between a sea-weed (*e.g.* fucus) and a flowering plant.

25. Describe the nature of the branching in the thallus of fucus. What is the use of the air bladders upon some of these plants?

26. Describe generally the "fall of the leaf." State what appearances you have noted in the leaves of elm and poplar in their autumn coloration.

27. Give a short account of an excursion in search of wild fruits in autumn.

28. Explain the terms "thallus," "sorus," "rhizome," "cupule."

CHAPTER VI.

ANIMAL STUDIES IN AUTUMN.

LESSON LI.

HOVER-FLIES (*Syrphidae*).

[These flies may be observed during the summer, visiting a large variety of flowers, especially Compositae and other open types of flower. It should be possible to recognise them from the notes given below. They are very easily captured, and may be examined in pill boxes with glass lids or in dry glass tubes.]

Outdoor Observations.—When the sun is shining brightly and the air is warm, you must go out of doors and watch for a little the insects visiting the flowers. You have heard a good deal about these insect visits in your flower studies, but you must spend some time beside the flowers out of doors if you are to properly understand what goes on, and you will also have a chance of seeing things which you may not happen to hear or read about.

Amongst the insects you are sure to see in the warm days of summer are those flies known as **hover flies.** They may be found on many different kinds of flowers, but one type upon which they are very common is the composite kind, such as the common **ragwort.** Take up a place near plants of this species and you will not have long to wait before you see their visitors. It is best to sit down quietly and to avoid sudden movements so as not to startle the insects and so cause them to leave. Now watch them as they come, settle for a little upon the flowers, busily probe and search, and then fly to another blossom. You will see different kinds, of course, and the class of some you will be able to readily distinguish, such as butterflies, or common flies.

Recognition Marks.—How can you recognise the hover-flies? In the first instance this will be easiest, I think, by **their flight.** Before they settle upon a flower they hover about in the air for some time, sometimes seeming to remain balanced motionless and then darting a little distance and again hovering stationary-like. The appearance of these flies differs a good deal according to the species, although in their habit of flying they are very much alike. Let us make some observations on the commoner ones. Upon the ragwort you are very likely soon to note some large **bee-like insects.** You are quite likely to mistake them for bees. Some of them are rather larger than the hive bee, tawny in colour generally, with dull yellowish marks upon the hind body. They resemble a humble bee.

If you note insects like these upon the ragwort, especially if you have seen their mode of flying to resemble the hover-fly, do not be afraid to capture them for closer study. A pupil generally hesitates at first, being afraid of getting stung, so much do these insects resemble bees. But hover-flies are quite harmless, they can neither bite nor sting you.

Eristalis—a Bee-like Fly.—Have some small dry glass tubes ready, or, better, small pill boxes with glass-topped lids. When the hover-flies are busy amongst the pollen or nectar you may take them unawares in the hand. Place some in the tubes or boxes and examine them. One of the commonest to be got in this way is a humble bee-like fly known as *Eristalis tenax.* We shall look at this fly and make some notes upon it.

First of all observe its marked resemblance to a bee. This is an illustration of what is termed "**mimicry.**" Mimicry amongst animals means a surface resemblance between two creatures which are really very different. It is generally the case that one of the two has some dangerous or harmful quality which serves largely to protect it from interference. Generally also the other is quite harmless. This latter is said to "mimic" the harmful form, and it derives protection from the resemblance because it is frequently mistaken for it. In the present case, the stinging powers which protect the bees also protect the harmless *Eristalis* from being meddled with.

Now let us see wherein *Eristalis* differs from bees. How many wings has it? You can see two only. But bees have four wings. If you can get a good view from the side or from below you will be able to see upon *Eristalis* the **two small knobs** behind the wings, which are peculiar to flies and which you never find upon bees or any other insects. Then look at the legs. Do you see any broadening of the shin joints such as are to be seen in bees? No, the leg of this insect has quite a different appearance from a bee's leg. It is not easy for you to examine the mouth parts, but these are quite different also from those of bees. This insect, then, is a fly, not a bee.

Let us make a general description of *Eristalis tenax.** It is an insect about the size of one of the smaller humble bees. The body is hairy, broad, and blunt behind. The hind legs are longer than the others. Upon the hind body there is at each side a large triangular tawny patch, and behind these the hind borders of the segments are of the same colour.

Do you know where this creature spends its larval life? Amongst stagnant muddy water. The larva is a very peculiar creature, without legs, and with a long slender tube at the hind end of its body. On account of this peculiar shape it is known as the "rat-tailed larva." The *Eristalis* larva is an air-breather, and this long tube is pushed up out of the mud to the surface of the water to enable the insect to breathe.

There are other kinds of *Eristalis*, some of them slightly smaller, which you may come across. They resemble an ordinary hive bee, and are thus another illustration of mimicry.

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* This cannot be done unless the pupils have an opportunity of seeing the flies.

Volucella.—I hope that while you are out on this insect hunt you will see what is a very handsome fly, viz. *Volucella bombylans*. I am sorry I do not know it by a simpler name, but perhaps when you know it by sight you will be able to invent one for it. It might well be called the **"red-tailed fly."** This is another hover-fly which visits composite and other flowers in the sunshine in summer. It also is a "mimic." It resembles a well-known humble bee which builds its nest amongst loose stones.

The body is rather short and stout, black, with the tip of the abdomen very red. It is well covered all over with long hairs. On each wing there is a dusky spot, and on the head a fairly long proboscis. The bee which it resembles (*Bombus lapidarius*) is a little smaller, but in general shape and colour is like the fly. But it can be seen to differ in the number of wings, the character of its hind pair of legs, and also in its feelers, which are comparatively long compared with those of the fly. You should learn to recognise both of these insects, and the best way to do it is to look out for them visiting flowers.

The volucella fly is interesting in another way. Its larvae live in the nests of humble bees, devouring their grubs.

Syrphus—a Wasp-like Fly.—There is one other very common fly belonging to this group which is readily recognised. One species of it may be seen in fruit gardens (*Syrphus ribesii*) hovering over currant bushes. Perhaps you have seen it, and mistaken it for a wasp. You are sure, I think, to see flies of this kind also if you are watching the flowers for insect visits. This fly has yellow bands on its hind body like a wasp (of which it is a mimic). In the currant species there are four of these bands, the first one of which is divided in the middle, and the fourth one may be also. The head is yellow, and the thorax is greenish with tawny hairs. Altogether these flies are handsome insects. Although at first sight you may mistake them for wasps, when you look a little closer you can see that they have not got the "waist" of the wasp, and they have only two wings, and, of course, they have not got the sting.

Hover-flies visit many different kinds of flowers, and are very important as pollinators. It has been said that they contribute far more to the pollination of our native flowers than all the other flies put together. They suck nectar where the length of their proboscis will permit them to do so, and also gather pollen.

You should make sure that you can recognise some of the commoner of these interesting and attractive-looking insects.

LESSON LII.

WASPS.

[This lesson may be conducted simply by reference to the pupils' experiences of wasps, although it will be more effective if a few dead wasps are available, and if possible a discarded nest. The lesson should be taught about the time when wasps begin to be numerous and troublesome, or when recollectlons of them are vivid, *e.g.* about the end of the summer term or beginning of autumn.]

Recognition Marks.—Most people think they know a wasp when they see one. To recognise wasps is not really a difficult matter, although we know there are other insects which are often mistaken for them (*e.g.* hover-flies, *Syrphus sp.* and *Volucella inanis*). Let us begin our lesson by pointing out the **recognisable features** about a common wasp (*Vespa vulgaris*). Write these down.

1. It is a fairly large insect, with **hind body showing black and yellow bands.**
2. There is a **waist,** or narrow part, a little way behind the wings. (Hover-flies have not got this.)

3. Their **feelers** are longer than those of bees, and much longer than those of flies. When the wasp rests you can see them quite easily.
4. When a wasp settles, its **fore wings are folded lengthwise.** Its wings therefore **appear narrow.**
5. We can also recognise it by its habits, such as its power of **finding sweetly scented stuffs** like fruits, flowers, or jam, and, of course, its power to **sting.**

Time of Abundance.—When are wasps most numerous? They seem to be most abundant towards the **end of a warm summer.** A warm summer, with plenty of flowers, juicy fruits, and flies, appears to be agreeable conditions for them. What do these things mean for wasps? They mean an **abundant supply of food** for both young and adult, and suitable weather conditions for the growth of the young grubs which then become very numerous.

Life History of the Common Wasp.—At what time of the year do wasps begin to appear? In the **spring.** What kind of wasps are these—male or female? These are **queen wasps.** Where have they come from? They have been sleeping (**hibernating**) all the winter in the earth.

Do any other wasps hibernate besides queens? No. What then becomes of the wasps which are sometimes so numerous in autumn? They all die as soon as food becomes scarce and the weather begins to be cold. If there are young wasps unhatched at this time the workers throw them out of the cells.

A Wasp's Nest.—When a queen wasp wakens from her winter sleep in spring she proceeds to make a nest. Have you ever seen a wasp's nest? What does it look like? Those we find upon trees form a globular papery-like mass, greyish in colour. (Exhibit one, if possible.) Examine this substance. Note how much it resembles a thin coarsely made paper. Where did the wasp obtain this material? She picked up bits of decaying wood, fibre, or similar substance, chewed it with a pair of biting jaws (mandibles) she carries in front of her mouth, mixed it with saliva, and moulded it into sheets which she shaped into the form you see. Of course it was not made so large to begin with (Fig. 133).

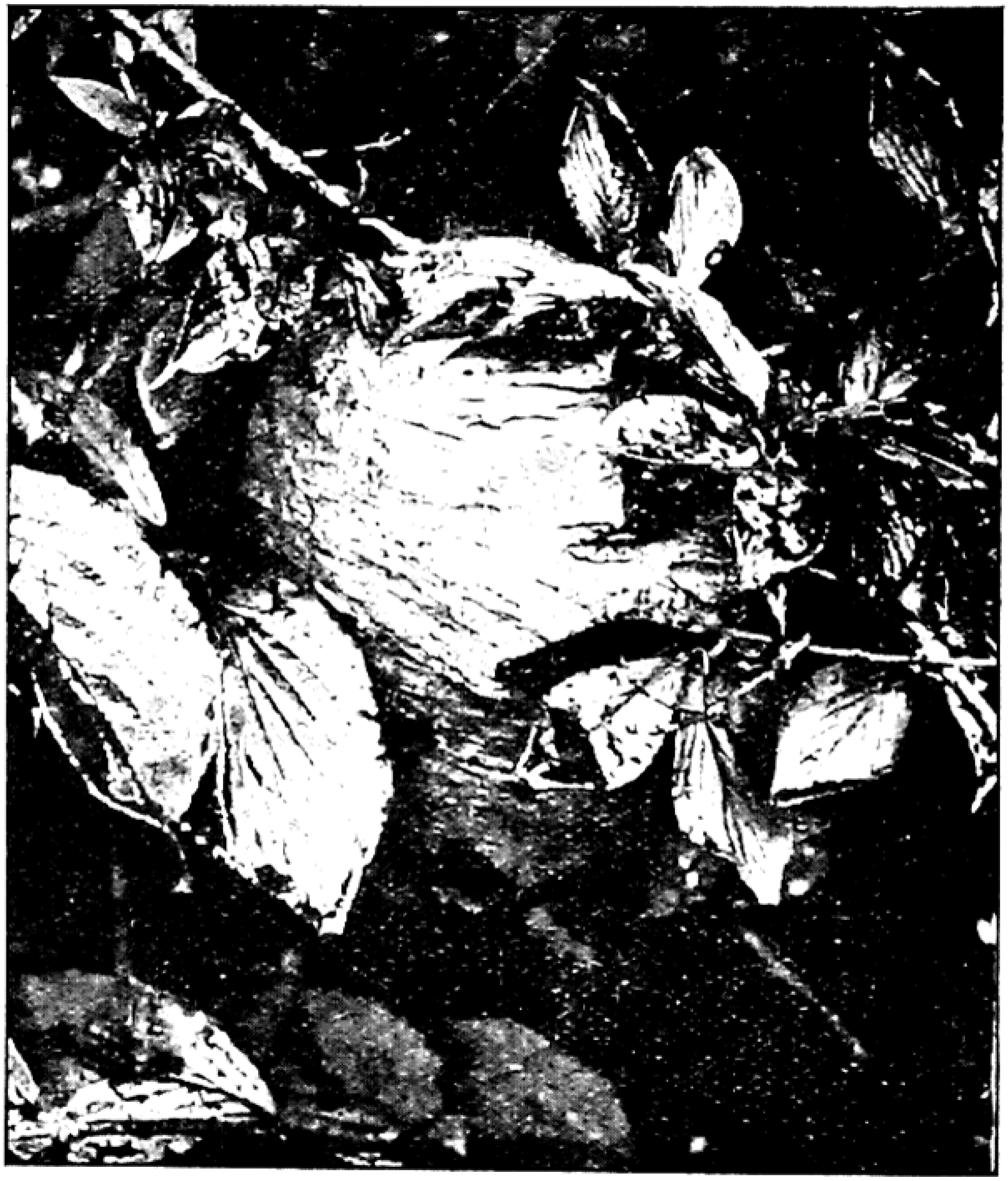

Fig. 133. A Wasps' Nest.

Inside the first small nest she built a few cells, similar in shape to those of a hive bee—six-sided—and in each of these she laid an **egg**. Soon **grubs** hatched from these, which she fed, at first probably with nectar gathered from early spring flowers; later they were fed with insect flesh, chiefly flies. These the wasps capture on the wing. The harder parts are cut away, the softer ones are partially chewed and offered to the larvae, which are said "to stretch out their heads to the mother to receive the food, after the manner of nestling birds."* The larvae in about a fortnight become pupae, and are in this latter condition for about ten days. Then they leave the cells. These are **worker wasps,** and they proceed, after cleaning their bodies, to assist the queen in making more cells in which she lays more eggs as before. Thus the colony grows, and as the numbers increase the queen confines her labours to egg-laying.

In the earlier part of the summer all the young wasps hatched are workers, but towards the end of the season males and queens are formed as well. As the numbers grow the workers make more cells, enlarge the nest, and tend to the gathering of food and feeding of grubs. When young wasps hatch out old cells are frequently used again for fresh grubs. The workers building fresh rows of cells join them to the old by means of short pillars, as you may see by opening the side of the nest. As the cells are increased in numbers the inner walls of the nest are removed to make room, fresh layers being built upon the outside.

In autumn they all die except a few of the young queens, which sleep through the winter and in spring awake and start a new nest.

Where is the nest made? The common wasp makes its nest underground, and so do some others. Some wasps, however, build their nests in trees or shrubs.

A question for you to think over is the differences between the wasp colony and that of the hive bee. That of the wasp lasts but one season; the hive bee colony lasts for years. It is enabled to do this because these bees provide food for the winter. The wasps, we have seen, do not do this. The humble bees are like the wasps, they also all die in autumn except some queens. The care of the young, however, which is exhibited by wasps is quite equal to that of the hive bee.

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* Sharp, *Cambridge Natural History.*

The Sting.—Perhaps you are interested in the sting of the wasp. It is rather a complex organ, and we need not talk about the details of its various parts. Like the sting of the bee, it is only borne by the females. We often see a fine point projecting from the tail of a wasp, and naturally think it is the sting. This is not the sting itself but a kind of sheath known as the **director,** which encloses the **"needles,"** of which there are two. The director pricks the skin first in the act of stinging, but the "mischief" is done by the needles and poison which flows between these into the wound.

Wasps are not nearly so ready to use their stings as is generally supposed. It is best to keep quite still or move quietly when they hover around close to one, or even when they settle on the skin or clothes. Haste or excitement are the very things to induce stinging.

If you should happen to get stung by a wasp, apply ammonia promptly to the spot and pain will be avoided.

Uses of Wasps.—Wasps are on the whole useful insects. Can you think in what way? They capture large numbers of injurious flies, especially such as are harmful in gardens and to farm crops, such as plant lice, earwigs, caterpillars, and bluebottle-flies. They also are of service as scavengers, for they devour and carry off flesh from small dead mammals, such as mice, cleaning these in a short space of time. Spiders are very much afraid of them. Wasps do damage to ripe fruit.

Solitary Wasps.—Besides nest-building (social) wasps like the common one, there are others which do not live in companies. Some of these build little clay cells on walls and such like places. These are **mason wasps.** They place a caterpillar, stung but not killed, in the cell along with the eggs, so that when the grubs hatch they may have living food beside them.

LESSON LIII.

A SNAIL.

[For this lesson any of the commoner of our land snails may be used, either the banded *Helix nemorosa* or *H. hortensis*. The familiar and somewhat larger species, with the rough shell found in waste places, *Helix aspersa*, may be more readily found. The species known as the Roman snail, or edible snail common on the Continent, may be got from dealers, and owing to its large size is admirable for lesson purposes. The most effective lesson will be taught by having several species for examination and comparison.

Have the snails in a glass vessel, supplied with some green stuff such as dandelion, cabbage, or lettuce leaves. If the snails incline to remain within their shells, place them for a short time in tepid water, when they will slowly expand.

A piece of glass should be available upon which to allow the snails to crawl.]

Observations of the Living Animal.—We shall begin this lesson by watching the snail and noting the various parts of its body. While we do so, we shall make a simple sketch. As we look down upon this animal from above we can see that the shell it carries on its back lies over with its point directed to the right side. The shell is nearer the hinder end of the body, but the animal can move it very freely, sometimes bringing it well forward and rotating it quite rapidly. A little way in front of the mouth of the shell is the animal's **head.** It is not very sharply marked off from the body, but is easily recognised because it carries two pairs of soft, tapering **horns** or feelers. Then we may chance to see it feeding, and in this way discover the **mouth** also at this end below the two pairs of horns.

The body stretches out flatly a little way behind the shell. The under side upon which it creeps is quite flat, firm, and tough; so also is the upper side of the body along the border and in the hinder part. Beside the colour and the marks or grooves upon the skin, which differ in the different kinds of snail, there is not much else of a general nature to notice at this stage. But having got the snail fully expanded and gliding along with fully extended waving horns, let us look at it closely and try to draw it, filling in as much detail as we can (Fig. 134).

The part the snail crawls upon is quite suitably termed its **foot.** You will notice it is not separated from the rest of the body, but that it forms its under or lower side. Have you now got the snail crawling on a piece of glass? If so, look below. Now, what do you see? I think it is

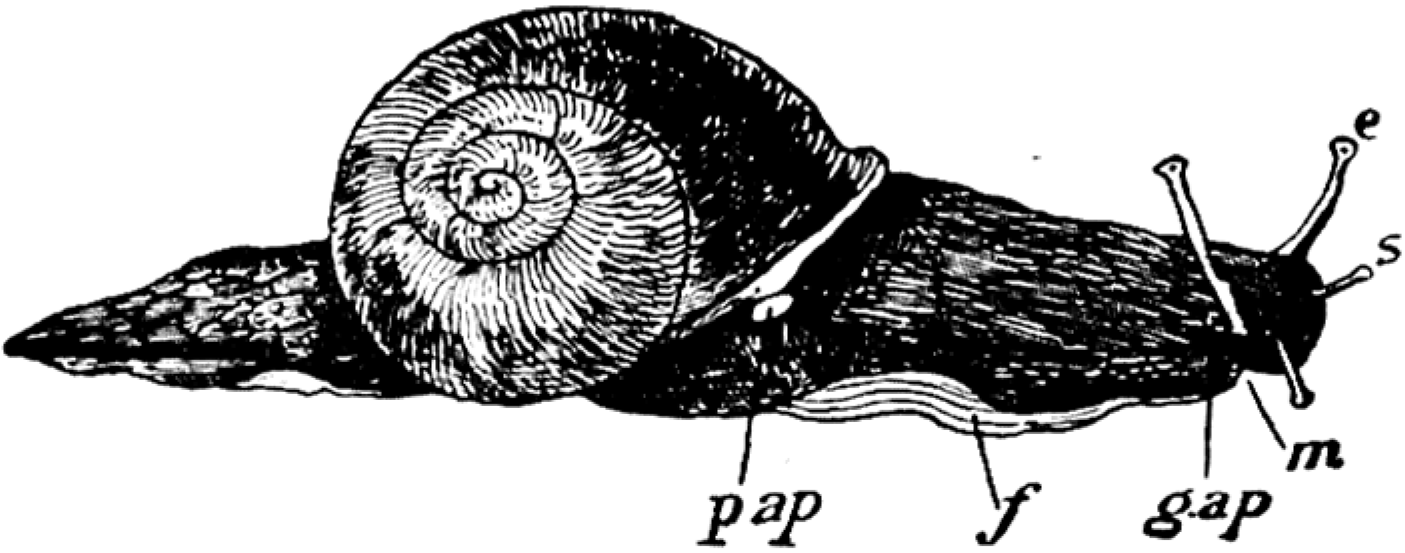

Fig. 134.—The edible Snail (*Helix pomatia*).
p.ap, pulmonary aperture; *f*, foot; *g.ap*, genital aperture; *m*, mouth; *s.h*, short horns; *e*, eye.

a very interesting sight. Many people think that a snail slides along the ground upon its own slime. But as you look at the underside of the foot you discover, do you not, that the snail is not sliding? It leaves a **slimy track** it is true, but you see a beautiful and steady flow of **waves** along the body passing from behind to the head end. As long as the snail is crawling they go on, and when they stop the snail stops moving. If you watch for a little you will find that this is so.

Now all this just means that the foot of the snail consists of a mass of muscle and that you are witnessing the regular **contractions** of this muscle which result in walking. The slime, in helping the snail to stick, gives " grip " to the muscles and so enables the animal to progress. We know that when we move our own muscles they contract and change their shape. A familiar example is that of the muscle which lies between our shoulder and elbow, called the biceps. Every boy has felt how his biceps changes shape as he moves his arm up and down. He notes its size with interest. Here also we can actually witness a muscle contracting. This is not a common sight because muscles are mostly concealed within the bodies of animals.

Now, if you have got the snail crawling steadily along the glass, gently raise the end towards which the snail's head is pointing, gradually bringing it up until at last it is quite perpendicular. What happens? In some cases the snail slides backward, but that is because its foot is wet. If the snail has been put in water to bring it out of its shell it may slide back, but a dry snail will not fall back. Notice that the **foot gradually expands** broadly to the sides so that it is greatly thinned out. When a snail is crawling up a wall it does this in order to get a **better grip.** You should measure the width of the foot at the broadest part when the snail is crawling, with the glass lying upon the table, and with it standing straight up. Of course the glass being very slippery, the foot spreads more than it does when the snail is crawling up a wall, and this shows you that the broader the foot is the better is the grip.

Rate of Movement.—You should measure off a short distance on the table and time the snail's rate of moving. Do this a number of times, add all the results together and divide by the number of times. This will give you the average rate of moving of the snail. Then try it the same way upon a sheet of glass, and upon a sheet of sand paper. Do you make out any difference *on the average* in the rate of movement in these three cases? Before you can draw a safe conclusion you will have to do the experiment a great many times. The rate in the rough snail (*H. aspersa*) is said to be about a mile in fifteen days.

(Perhaps the teacher will be able to arrange a careful and fairly extensive experiment on these lines.)

Breathing.—Do you know how a snail breathes? You can discover this best by making the snail go back into its shell. When you watch the soft flesh of the snail filling up the opening of the shell you see from time to time a **round hole** appearing and then closing up again. When a snail is crawling upon the glass look under the edge of the shell well back on the animal's right side and you may be able to see the same opening appearing and disappearing. The snail has just under the widest part of its shell and lying close to it a very thin fold of skin termed its **mantle.**

Beneath the mantle is a large space within which air moves freely, passing in and out at the opening we have just been looking at. This passage of air outward and inward is helped by the ordinary movements of the snail in creeping. The mantle in the snail is a **kind of lung,** and when we witness the passage of air into the space beneath we are watching the snail breathing. The mantle is covered with a fine network of blood vessels; the heart is here also, and as the blood takes up oxygen from the air it is driven by the heart through the body.

Food.—I hope you will be able to see the snails feeding. They have a pair of **horny lips** with which they seize the food, and a **flat toothed ribbon** (radula) in the floor of the mouth upon which they rub and tease it. As this ribbon gets destroyed in using it goes on growing behind from a little sac which lies at the back of the mouth cavity. These snails are entirely vegetable feeders. Slugs take animal food more or less, as well as plant substances.

Senses.—Notice next how sensitive this creature's skin is. Touch it lightly at any point, and especially along the margin, and observe what happens. The part touched contracts at once and draws away.

Besides being sensitive all over the body the snail is specially so upon its horns. Watch how these are waved in the air as the creature moves along, and how quickly they answer to the lightest touch. Test their sensitiveness with a pencil or other finely pointed instrument.

If we touch it repeatedly it will at length draw itself entirely within the shell. When it proceeds to do so, notice the order in which the parts pass out of sight. The head being the most sensitive region is first protected; the foot, folded in the middle line, is the last to disappear. The hard shell you thus see is meant to protect the animal against interference. But we know that the thrush has learnt to break the shell upon a stone, and thus get at the soft body which is for him a delicious morsel.

Eyes.—The snail is provided with a pair of **eyes.** Have you noticed where these are placed? Look at the tips of the long horns. These black specks towards the upper side of the tip are the eyes. Touch them lightly. Where do they go? Repeat the experiment until you understand what is happening.

Now try approaching the eyes carefully with a pencil, and note how near you can come before the eye is moved out of the way. The snail does not appear to see very far ahead, but it may see moving objects readily. At any rate it responds more quickly to the pencil moved in front of it, but here we must remember that it feels the current caused in the air by the motion of the pencil.

The snail has other senses, but these we cannot test so readily. It has got a so-called "hearing organ" placed within on the fore part of the foot, and it certainly can **smell** well by means of its horns. It scents food some distance away. You might cover some food in a box, shutting in the snail with it, and note how soon the food is found although it is hidden from sight.

I hope you will now be better able to understand the life which a snail leads. It moves about its little world rather slowly, carrying about with it a shell to protect it when danger threatens. It destroys man's plants in field and garden by means of its file-like tongue, finding its food most readily by its sense of smell. And when food is scarce in winter it burys itself and goes to sleep. The large Roman snail shuts up its shell with a limy plate like a thick egg-shell.

In a second lesson the pupils might be asked to compare the parts visible in a slug with what they have observed in a snail. Two common slugs are readily obtainable, viz. the **Black Slug** (*Arion ater*), and the **Grey Field Slug** (*Limax agrestis*). These differ from the snails in having no spiral shell, although a vestigial shell exists embedded in the oval area in front. Note the breathing opening on the right side of this area, near the front in *Arion*, at the hinder end in *Limax*. Drawings of the slugs showing the right side should be made. *Arion* may occur in gardens but is commonest by waysides and in waste places. *Limax agrestis* is a troublesome pest of gardens and field crops.

LESSON LIV.

BIVALVE SHELLS.

[A collection of bivalve shells should be made. This may be done on the occasion of a visit to the seashore, or supplies may be got in other ways. For the lessons below the forms named are required. To assist the teacher, descriptions of common shells are given at the end.]

A Collection of Shells.—As we look through an ordinary collection of shells such as we have here, we find they can be readily made up into two groups. It may be that there are a few about which we are a little doubtful at first, and if so we can put these aside for the present. The others we arrange in two lots, because as we handle them we discover that there are shells which are entirely made up of one piece and others which consist of two separate pieces or valves. Here, for example, is an ordinary snail's shell. It consists of a single piece, spiral in form. On the other hand, look at the shell of an oyster or of a mussel, and you see that the complete shell consists of two pieces. When you gather empty shells upon the seashore you do not always find the two halves of such shells together—indeed, you usually find the halves, or valves as they are termed, separate.

Shells which consist of two pieces are termed bivalve. We have not got such a simple name for the other kind, but as they are nearly all spiral in shape, we shall call them spiral shells. We shall now talk for a little about shells.

Names of Common Shells.—First of all I think we might learn the names of a few common forms. For the present we shall deal only with the bivalve type (Fig. 135).

Mostly everyone knows the **mussel** and the **cockle**; you recognise them at once. What is the long narrow one which you often find upon sandy beaches? This is known as the **razor shell.** This small pretty one with the well-marked grooves upon the outside and brownish bands is known as a **Venus** shell. This other one, a little larger, thinner, and smoother, also with brownish rays upon the outside, is called the **"fool's mussel,"** whilst this large thick one, brown upon the outside and white within, from its size and shape is termed the **saucer shell.**

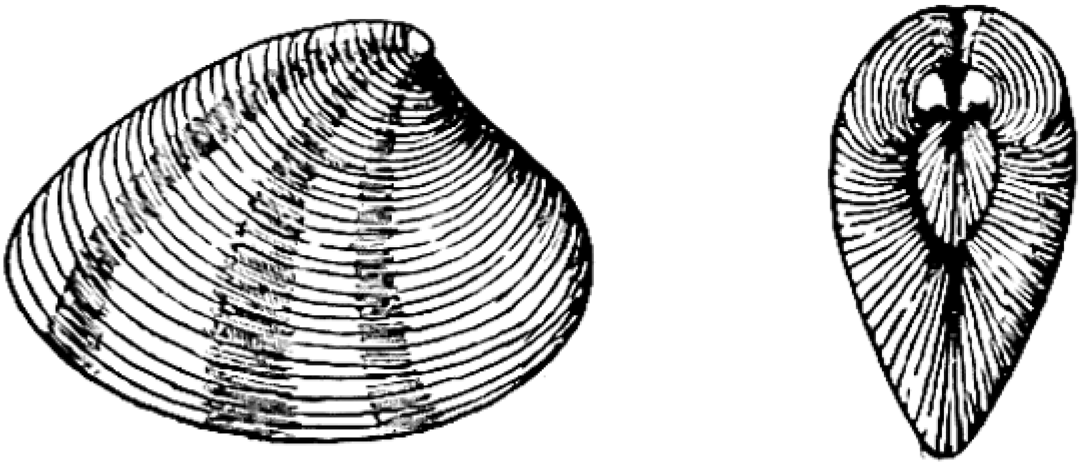

Fig. 135.—A Common Sea Shell (*Venus gallina*).

Write down the names of these six shells, look at them closely, notice their special marks, and make sure that you will know them by name when next you see them (Figs. 136, 137).

Now let us ask some questions. **What are shells?** On land you have seen snails with spiral shells upon their backs, and in the rock pools on the seashore, periwinkles and dog whelks, which are just sea snails also with spiral shells. Mussels and other bivalves also are sometimes found with the animals within. You already know, therefore, that shells are hard parts surrounding the bodies of animals which otherwise are very soft.

Use of Shells.—You can see the use of the shell to such animals. The snail in times of danger, or when it hibernates, goes inside, in this way protecting its soft body. The mussel closes its valves tightly when the shell is handled, saving itself from attack by this means. You have noticed, too, have you not, that the bodies of some of these creatures are so soft, for example mussels and oysters and some parts of snails, that the shell is needed to hold or support these parts in their proper positions.

Shells give both Protection and Support.—Hard parts in animals' bodies which do that are called skeletons. In this sense these shells are really **skeletons,** although we do not usually call them such. There are other creatures which wear their skeletons upon the outside, for example, insects and spiders. The tough skin upon these creatures serves the same purpose as the shells we are looking at. This kind of skeleton is called an **exoskeleton,** or outside skeleton.

Now we may learn the name of this kind of animal which forms a hard shell on the outside of its body. It is called a **mollusc.** Snails, slugs, oysters, mussels, clams, and such like creatures are all molluscs.

Enemies of Molluscs.—The creatures which make these shells run many risks and have many enemies. Sea birds and some fishes are powerful enough to break the shells. The birds drop them on the rocks or swallow them, the fishes swallow them whole or crush them with strong teeth, as is the case with the wolf fish (*Anarrichas lupus*). But apart from these, the molluscs are very safe from most other attacks, because of their shells. (In another lesson you will learn how a starfish opens a mussel—a remarkable feat.)

Study of Markings.—If you look at these bivalve shells closely, you will see that there are certain marks upon them. Would you like to learn to read the marks upon the shells? They are not difficult to read and they are very interesting.

Take the saucer shell in your hand. You know that at one time a soft-bodied animal lay within its valves. On the outside of its body a fold of skin hung down from the back over the two sides like a loose cloak, concealing all the other parts. This fold is very suitably termed the **mantle.** It lay against the inside of the two halves of the shell and during life was fixed to it a little way back from the edge. If you look at the inside of the shell you will see the line along which the mantle was attached. It follows the edge of the shell, but is a little way back from it. This line is called the **mantle line.**

Make an outline drawing of the shell, showing the inside, and mark upon it the mantle line (Fig. 137).

Here we have some questions to answer. How has this shell come to be as large as we see it now? It is a hard dead thing, without softness or feeling, yet it was not always of this size. It must have grown. How has it grown? We are sure it has not grown since the animal left it. Shells without living animals within them do not grow. And now when you remember that the part of the living animal which lies next to the shell is the mantle, you will readily understand that the shell is made by it, increasing in size along the edge and in many cases in thickness all over the inner surface.

Look now at the outside of the shell. Do you see the ridges which pass round it, marking successive additions to the shell? These may be called **lines of growth.** By tracing them backward we arrive at the oldest part of the shell. Find the oldest part of the shell. It will be seen to be turned downward, and nearer to one end than the other. This part is termed the **beak,** and it is turned towards the front end of the animal. By noting this we can tell from the shell where the head end of the animal lay.

Here is a simple exercise. The halves of the shell lie at the sides of the animal's body. How can we tell whether the valve we hold is a right half, or a left half. First, let us name the regions we know. We have just discovered the anterior or front end. The opposite end is, of course, posterior. The free open edge (growing edge) of shell is the under side (ventral side), hence the part where the valves join (hinge region) lies next the back (dorsal side). Now apply the following rule. Hold the half shell in the hand with the front end directed upward and with the inside of the shell towards your own body. Next move the shell towards that side of your body which will cause the growing edge to be directed forward, and the hinge margin towards your back. You will occupy the same relative position to the shell which the animal did when living, and if the shell is a right half it will be held at your right side, and if a left half, at your left.

Repeat the exercise with several different shells.

Note next the layers of the shell. On the outside we can recognise a dark-coloured horny-like covering. Different kinds of shells examined will show that it is strong in some and very thin in others, and in shells which have been dead a long time it may be all rubbed off. This substance, known scientifically as conchin, may also be called **"shell stuff."** Look at this shell stuff in different kinds of shell. Viewed from the inside the shell shows a third layer, which is made of lime. The surface of this layer shows a certain amount of glossiness, which in some shells produces a marked iridescence. This is known as the **mother-of-pearl layer,** and it is from this part that various useful and ornamental articles are manufactured, *e.g.* buttons, knife handles, etc. In the saucer shell it is an opaque white. Between the two layers named there is a **middle layer,** also limy, but this layer is always dull.

An examination of the shell shows that it is thicker in the older parts than in the newer. This is because the mantle not only adds to the shell along the edge but to its inner surface also, and it is to the innermost layer that the addition in thickness is made. It is owing to this property of the surface of the mantle that the occurrence of pearls inside shells is due. When pearls are made they are formed by the mantle making a layer of mother-of-pearl around some body which has got inside between the shell and the mantle. It is, strange to tell, usually a small parasitic worm.

When bivalves are found alive, their shells are tightly closed. You will know how tightly these animals can shut their shells if you have ever tried to open a live mussel, clam, or oyster. The shells are closed so tightly that it is found impossible to open them without the aid of a sharp instrument. Bivalves are provided with powerful **muscles** passing across from shell to shell, by means of which they pull the two halves of the shell together. Oysters and clams have only one such muscle, but most others have two. Examine the inside of the saucer shell and find at each end of the mantle line an oval scar (Fig. 137). This marks the place of attachment of the shell-closing muscles. You must add these marks to your drawing of the shell.

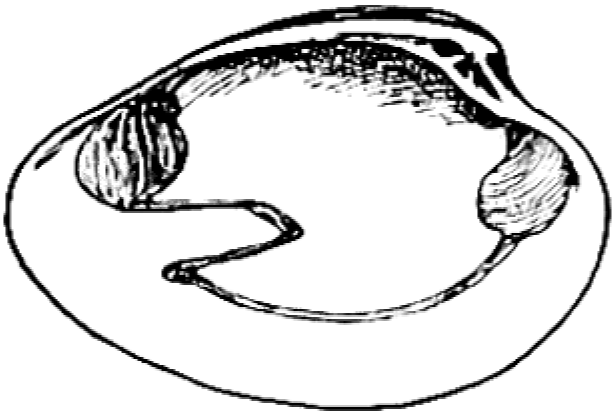

Fig. 136.—Inside of valve of *Mactra stultorum*, showing adductor muscle marks and indented mantle line.

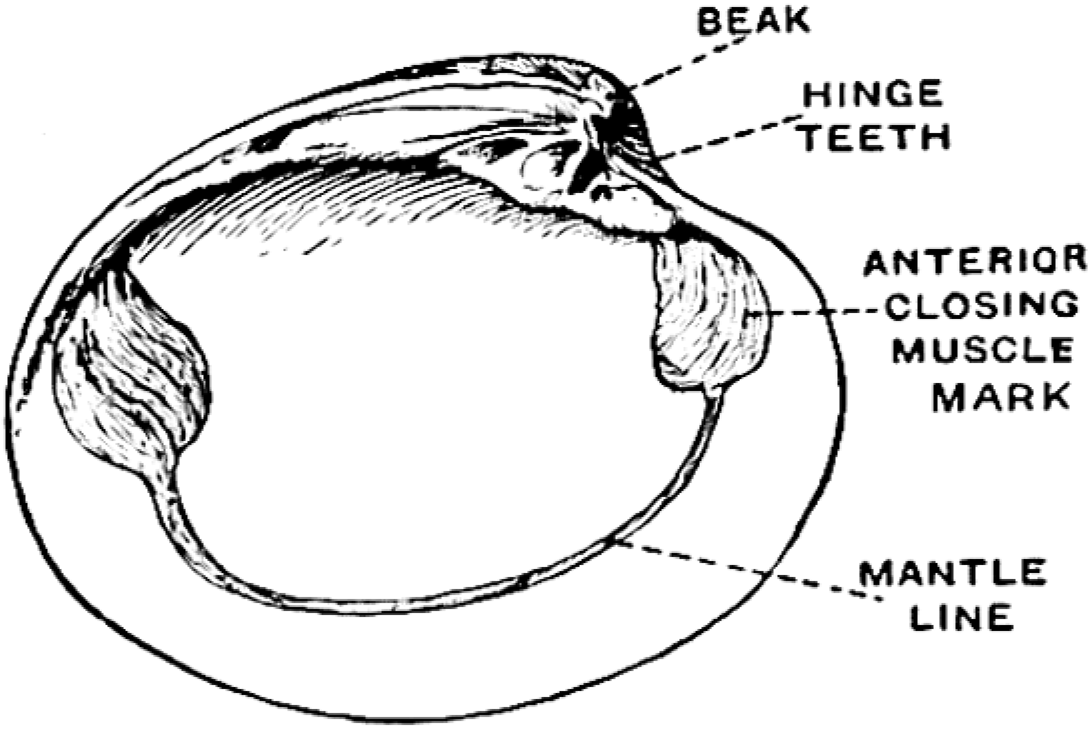

Fig. 137.—Left Valve of Saucer Shell, showing markings on the inside.

In some shells the posterior end of the mantle line is indented into a kind of **bay** (Fig. 136). Common shells showing this are the "fool's mussel" (*Mactra stultorum*), the Venus shell (*Venus gallina*), and the large well-known sand mussel (*Lutraria elliptica*). Find this bay upon these shells. This bending of the mantle line is due to the presence of a breathing tube in these animals. This tube projects from the hinder end of the shell but can be more or less drawn within it. It is used as a means of conveying water in and out of the shell. The water carries in oxygen for breathing and food also. The presence of a "bay" on the mantle line, therefore, tells us that the animal had a breathing tube attached to its body.

Just below the beak of the shell you can see the ridges which lock the two valves together. They form part of the hinge, and are known as the **teeth.** They help the animal to keep the shell closed when it is in danger. When a mussel is lying at rest, however, its shell is always partly open. This is due to the pulling effect of the conchin which joins the two valves above the hinge, and also in many cases to the presence of a firm but more or less elastic pad which lies between the two valves above the teeth apparatus. This pad is compressed when the valves are held together, it causes them to separate when the pull of the muscles is relaxed. In the Saucer Shell the pad is long, in the Scallop and Sand Mussel it is short, thick and triangular.

Finish your drawing by filling in the teeth and naming all the marks you know the meaning of.

SHORT DESCRIPTIONS OF COMMON BIVALVE SHELLS

(For Assistance in Identification, etc.).

Oyster (*Ostrea edulis*).—Shell whitish, thick, foliated externally. Beak pointed, anterior. Hinge toothless, pad transverse. Posterior adductor muscle mark only. Inner surface white, slightly iridescent. Upper (right) valve flat or slightly convex ; under (left) distinctly scooped.

Fan Shell, Scallop, Clam (*Pecten opercularis*).—Shell approaching a circle, with "ears" around beak. Reddish externally with radiating ridges from beak to margin. Margin in consequence fluted. Upper valve (left) flat. Rests on right (more concave) valve. Anterior ear of right valve with notch. Whitish inside, slightly iridescent. Triangular pad, blackish, in pit below beak. Posterior adductor only, large; pallial line faint.

Common in deep water, on hard ground. Empty shells abundant.

Common Mussel (*Mytilus edulis*).—Wedge-shaped, beak pointed forming anterior end of shell. Size about 2 inches. Conchin bluish-black. White inside with dark blue margin. Anterior adductor ventral and close behind beak, small, crescentic. Posterior mark larger and more dorsally placed.

Horse Mussel (*Modiola modiolus*).—Similar in shape to *Mytilus*, but larger, over 6 inches from beak to posterior margin. Often denuded of conchin, and then pale purplish. Markings as in *Mytilus*.

Not uncommon on rocky coasts. In deep water.

Pectunculus glycimeris.—Shell nearly circular, thick, brownish externally, beak median in position, hinge long with numerous teeth spreading laterally. Inner surface smooth showing radiating lines and with wavy margin, white or stained with brown. Adductors dissimilar in form, no pallial sinus.

The River Mussel (*Unio margaritifera*).—Large, elliptical, 4½ to 6 inches from back to front, thick, conchin black. Beak distinct, shell always fractured around it, exposing middle or prismatic layer. Lines of growth well marked. Hinge teeth prominent, pad elongated. Inner surface scarred, showing bluish pearly lustre. Adductor marks and pallial line distinct.

Common in rivers in muddy and gravelly places.

The Fresh-water Mussel. Swan Mussel (*Anodon cygneus*).—Large, elliptical, about 5 or 6 inches from front to back, generally thin, conchin greenish or brownish. Beak not prominent, lines of growth well marked. Teeth absent. Shell markings indistinct. Inner surface slightly iridescent.

The Cockle (*Cardium edule*).—Shell ribbed, deeply concave, whitish or light brown. Beak almost median slightly anterior. Lines of growth not numerous, widely apart on older region of shell. Internal surface also ribbed, not iridescent. Hinge teeth present. Adductor marks fairly clear, pallial line faint.

Sandy bays, near low water. Estuaries.

Cyclas rivicola.—Shell rounded, dilated, somewhat thin, conchin yellowish brown, or brown, strong. Size reaching to ¾ inch from anterior to posterior margin. Inner surface bluish white, markings not visible. Teeth anterior, median, and posterior.

Small species inhabiting the rivers of the north temperate zone.

The Saucer Shell (*Cyprina islandica*).—Large, nearly circular, 4 inches or less from front to back, thick, conchin brown or blackish. Beak prominent, lines of growth well marked. Hinge teeth large, pad elongated, adductor marks and pallial line prominent. Inner surface white.

Not uncommon along sandy coast, frequently cast up on beach.

The Venus Shell (*Venus gallina*).—Shell small, colour light, with brownish bands radiating from beak to margin. Convex but flattened along dorsal margin. Growth lines well marked. Beak anteriorly placed. Heart-shaped depression in the frontal slope below the beaks. Interior white, pallial bay present (Fig. 135).

Common on beaches.

Tapes pullastra.—Shell somewhat broadly elliptical, white or pinkish, with close set even ridges (growth lines) showing grouping (seasonal growth periods). Beak at anterior fourth. Ligament fairly long, teeth prominent more or less bifid. Inside white dull and glossy. Markings clear, pallial bay present, deep, rounded.

Animal buries itself in sand at low water, or hides in rock crevices or sea-weed roots.

The Fool's Mussel (*Mactra stultorum*).—Triangular with rounded margin. Extreme dimension over 2 inches. Beak centrally placed, perhaps with slight inclination anteriorly. Colour, pale with radiating lines from beak to margin. Internally white, sometimes pale purple. Hinge teeth well marked. Adductor marks and pallial bay clear (Fig. 136).

Sandy coasts, buried just below the surface.

The Thick Mactra (*Mactra solida*).—Shell triangular with rounded ventral margin, whitish, thick, smooth or glancing on both surfaces. Beak almost median, anteriorly inclined. Lines of growth mostly faint or obliterated in older shells, but growth periods clearly marked by prominent lines. Internal surface white, more or less polished, especially adductor marks and along margin. Pallial bay present, well marked.

Common along the sandy coast. Empty shells common on beaches.

The Sand Mussel—Otter's Shell (*Lutraria elliptica*).—Shell large, elliptical, long axis over 5 inches, gaping at both ends, thin. Conchin brownish or greenish, membranaceous, peeling off readily. Beak about $\frac{1}{3}$ length from anterior end. Inner surface white, glistening or dull. Hinge teeth prominent, pad triangular, but often missing from empty shell. Adductor marks and pallial line very clear. Large pallial bay.

Occurs buried vertically in sand or muddy estuaries.

Tellina balthica.—Small, rounded, whitish with pink bands following lines of growth. Area around beak frequently pinkish, beak almost median. Inside rosy pink or whitish. Usual markings distinct.

Tellina tenuis.—Small, elliptical, fragile, glossy, translucent, usually whitish tinged with pink. Hinge teeth distinct, adductor marks and pallial line clear.

Found on sandy beaches.

The Wedge Shell (*Donax anatina*).—Shell elliptical along lower margin, angled dorsally, polished, yellowish or purple with extremely fine lines radiating towards margin. Margin finely serrated. *Beak directed posteriorly.* Internal surface variable, white, yellowish, or purple, usually polished, pallial bay large.

Common on sand near low water mark, an inch or two beneath the surface.

The Razor Shell (*Solen siliqua*).—Shell elongated, 6-7 inches, with dorsal and ventral margins parallel, depth dorso-ventrally about 1 inch. Surfaces curved, the two valves gaping at both ends. Moderately thick, conchin greenish brown, long tapering triangular mark from beak to posterior edge. Internally whitish, glistening; teeth at extreme anterior end. Anterior adductor long and narrow, pallial bay at posterior end behind posterior adductor.

Lives buried vertically in sand at extreme low water. Empty shells on beaches.

Saxicava rugosa.—Shell whitish, oblong, gaping, rugose with prominent lines of growth, beak rather elevated above dorsal margin. Hinge toothless, pallial line uneven.

Found in crevices of rocks amongst roots of sea-weed, and burrowing in limestone, etc.

The Piddock (*Pholas dactylus*).—Shell widely gaping at both ends, more or less cylindrical, with accessory valves in dorsal region around and behind the beak. Surface of shell ridged. Whitish. Pallial bay reaches to centre of shell.

Bores in limestone and other rocks.

Where a collection of shells is available, the class should be given a series of exercises in drawing and description. With the help of the foregoing, the teacher should be able to guide the pupils in observing and noting distinguishing features.

LESSON LV.

SPIRAL SHELLS.

[A collection of shells such as are enumerated and briefly described below should form part of the school "nature study" equipment. It can be got together by degrees without much trouble. Those suggested are either British or such foreign ones as are extremely common in this country, and may be obtained at dealers' shops for a few pence. The shells can be used for lesson purposes in various ways, some of which are suggested below.

The brief descriptions given below are supplied (1) to enable the teacher to identify the commoner examples to be found in Britain, (2) to act as a guide as to the features towards which the attention of pupils should be directed in their exercises in description. It is not intended of course that the same terminology be required of the children; although in comparing shells it is necessary that the details of structure should be familiar and the names of the various parts understood.]

I. **The Shell of the Garden Snail,** *Helix aspersa* (a live snail with the shell on its back should, if possible, be exhibited as an accompaniment to the lesson).

You have here a shell of the garden snail. Before we begin to study it closely, look for a moment at the animal of which it is really a part. Notice the use the creature makes of it and how easily the shell is moved about as the animal creeps.

Composition and Relations of Shell.—Have you learned what part of the animal makes this shell? Its mantle. Can you tell of what it is made? Carbonate of lime; and to this there is added the horny substance (conchin) you see upon the outside (see p. 306). It is not difficult for you to understand the value of the shell to the animal, because you see the use it is constantly being put to. It is a protective structure for the animal's soft body at all times, and particularly in winter, for during this season the animal hibernates within it.

Is the snail attached to the shell? Yes, you cannot draw a snail out of its shell without tearing certain ligaments which bind the two together.

The Parts of a Helix Shell.—Let us now learn the names of the various parts. In order to do this we must draw the shell. Place it in front of you with the tip directed upward and the mouth of the shell facing you and towards your right hand. The following names must now be written upon your drawing and learnt by you. The tip of the shell we call the **apex.** The coils from just above the level of the mouth to the apex are together known as the **spire.** The spires of some shells are very low and broad, others are very tall and narrow. There may be few or many turns in the spiral of a shell. The spire of this shell is of an intermediate type, not very high and with few coils. The lines or grooves between the turns of the spiral are termed the **sutures.** They are deep and well marked in some shells, in others less so. We count the turns of a spiral shell in the following way.

Start from the uppermost corner of the **mouth** of the shell to a point in the suture immediately above it. This distance round the shell counts one **whorl.** Another round to a point immediately above this counts another whorl, and so on. The surface of a whorl may be flat or convex, smooth, ridged, spiny, or knobbed, and so on. In this shell the whorls are fairly smooth and convex.

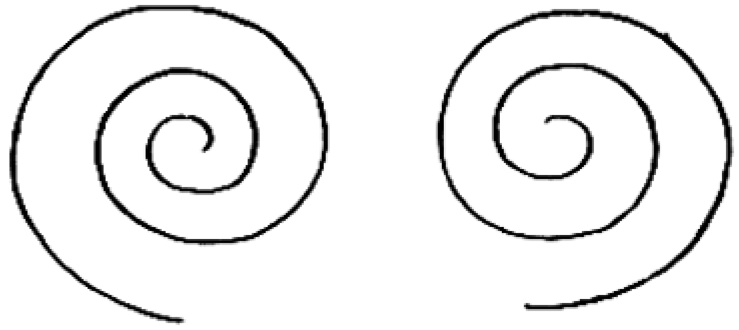

Fig. 138.—Spirals; that to the left is left-handed, to the right is right-handed. In following the spiral commence at the inner end.

Note that the spiral is right-handed. To determine this, look down upon the apex of the spire, and follow the coils downwards with the finger. The finger will move in the same direction as do the hands of a watch. Some shells have a contrary spiral, *i.e.* they are left-handed. Draw a left-handed and a right-handed spiral side by side (Fig. 138).

When you write a description of a shell, these are the things you must pay attention to. The appearance of the mouth must also be noted, both inside and on the margins. Also the **colour** of the shell as a whole requires mention.

Description to be made.—Having named the foregoing structures in your drawing you must now write a short description of this shell. State first its size. Place it upon the page of your note-book, holding it level by the right hand. Look directly down upon it and mark on the page a dot in a line with the apex of the spire, and another dot in line with the lowest part of the shell. The vertical line between is the height of the shell. Similarly mark a dot at the level of the uppermost corner of the mouth. The vertical space between this and the apex dot is the height of the spire. Having made these measurements you can now express the spire height as a fraction of the total height of the shell. You should also in a similar way measure the width of the shell at its broadest part.

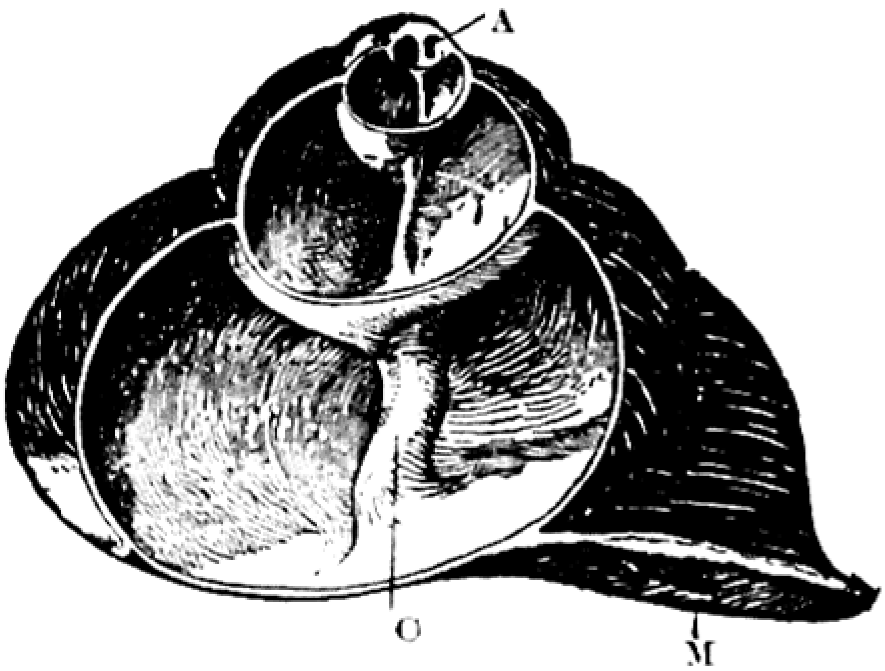

Fig. 139.—Shell cut to show pillar (O). M, mouth ; A, apex.

Next should come an account of its general appearance. Brownish yellow in colour, with four longitudinal bands of blackish brown, interrupted by yellowish, irregular lines or spots—shape globular, spire short [$\frac{1}{4}$ to $\frac{1}{3}$], sutures distinct, whorls convex—mouth roundish, the margins even, thickened and folded back, whitish internally—an opening under the folded back margin on the inner side.

Pillar Opening.—The foregoing are the chief things for you to note in a description. To complete the account, however, we may add the following.

Up the inside of such a shell there runs a **central pillar** (Fig. 139). In a broken shell this pillar is easily seen. To it the ligaments are attached, supporting the soft parts of the animal within. The small opening we have noted upon the outside leads a little way into the interior of the pillar. It is known as the pillar opening (*umbilicus*).

II. Write descriptions accompanied by drawings of a whelk's shell, a tower shell, a cone shell, a cowrie shell, an ear shell, a limpet, a ram's horn shell. Other shells, as may be convenient, may be taken, but the foregoing illustrate particular features and together yield suggestive points for a lesson on spirals.

Whelk—a central type with moderately long spiral (Fig. 140).
Tower—a long spiral (Fig. 141 B).
Cone—a short spiral, many whorls, but much over-overlapping (Fig. 141 A).
Cowrie—a short spiral, few whorls, with much overlapping (Fig. 142 A).
Ear—open spiral, no pillar, unsymmetric (Fig. 142 B).
Limpet—spiral obliterated—shell cap-like (Fig. 141 C).
Ram's horn—flat spiral; all the others are turreted spirals.

* DESCRIPTIONS OF SOME COMMON GASTEROPOD SHELLS.

(*Mostly Spiral in form.*)

TERRESTRIAL.

HELIX SPECIES.—**The Rough Helix** (*H. aspersa*).—Shell globular with short spire, mouth roundish, the margin thickened and reflected. Colour brownish yellow, with four longitudinal bands of blackish brown, interrupted by yellowish irregular lines or spots. Margin white internally. The colour and markings are rather variable. Found in gardens, about old walls, hedgebanks, old churchyards, chiefly along the coast.

The Garden Helix (*H. hortensis*).—Shell small, $\frac{10}{12}$ inch in diameter, spire low, whorls convex, colour yellow, with five longitudinal brown bands, margin reflexed, white inside. Beside the banded form there is a yellow form without bands.

Common in pastures, about walls and banks.

The Woodland Helix (*H. nemoralis*), resembling *H. hortensis*, but the lip is brown, not white, internally.

The Roman Snail Shell (*H. pomatia*), similar in form to *H. aspersa*, but larger. Light brown with three pale bands on last whorl, indistinct on others.

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* In some instances these descriptions are adapted from MacGillivray's *Molluscous Animals*.

MARINE.

The Whelk or "Buckie" (*Buccinum undatum*).—Shell from 4-5 inches long, 2-2½ inches broad. Conical, tapering to a fine point, the whorls convex, striated longitudinally, with well marked ridges. Sutures well marked. Mouth elongated, oval, notch well marked, inner surface whitish, tinged with yellow. Colour reddish usually, conchin rather hairy in texture (Fig. 140 A).

Common. Often cast ashore. Egg cases in big clumps, about the size of an orange, whitish, membranous, tough. Common on beaches after storms.

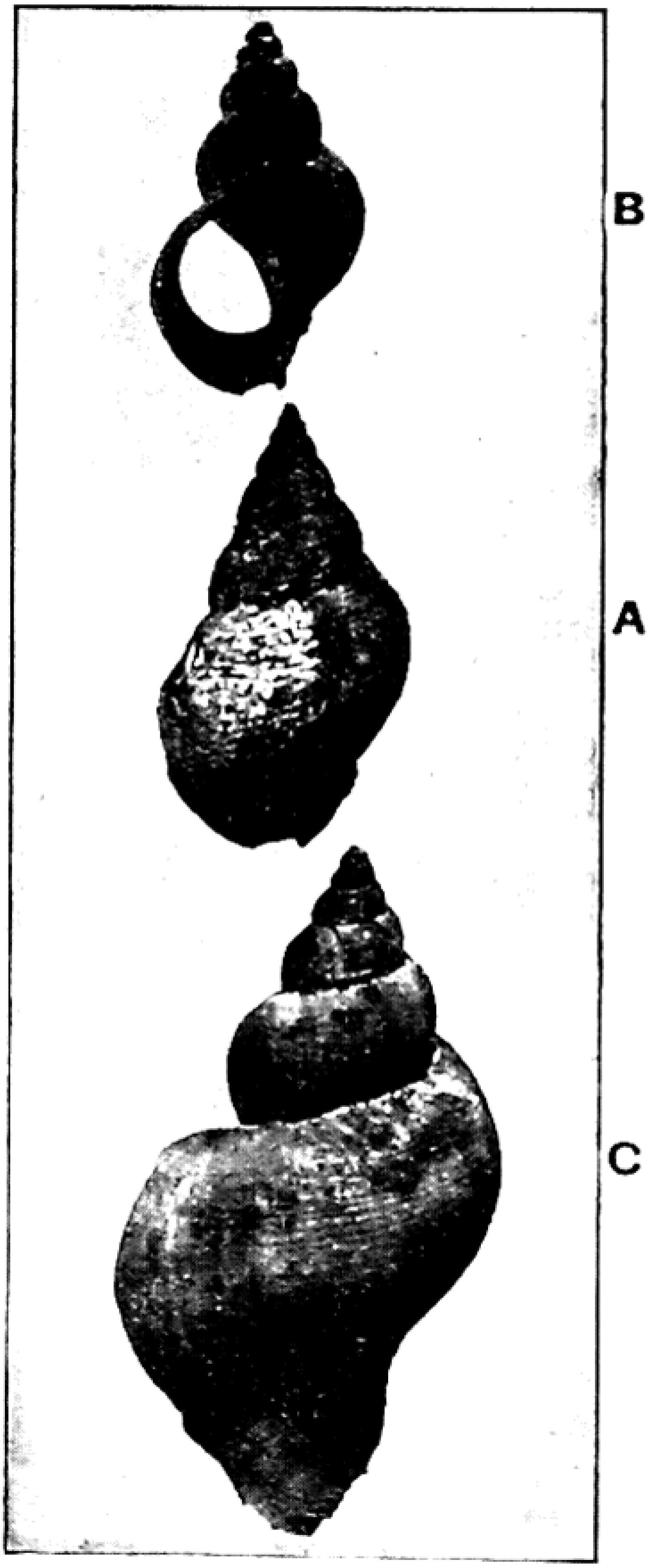

Fig. 140.—A, Shell of Whelk (*Buccinum*).
B, Shell of Whelk sectioned.
C, Spindle Shell (*Fusus*).

White Spindle Shell (*Fusus antiquus*).—Shell large, resembling Buccinum in general form, with pointed spiral and convex whorls, the last dilated and broader than the length of the spire; well marked longitudinal and fainter transverse striae, which become prominent at the notch. Mouth oval, smooth lipped, with prominent notch, umbilicus concealed. Colour of shell whitish; inside white, yellowish, or orange. Five or six inches in length, breadth more than half the length (Fig. 140 C).

Common in deep water on hard bottom off coast; frequent on fishermen's lines.

Dog Whelk (*Purpura lapillus*).—Shell may be over an inch in length, and about a half-inch in breadth—thick, somewhat bluntly tapering, last whorl large and longitudinally striate. Mouth elliptical, notch small, slightly recurved. Colour usually white with purplish tint at mouth —frequently light greenish.

Common on all rocky coasts.

Cone Shells (*Conus sp.*).—Shell conical, tapering evenly, spire very short or quite flat with numerous whorls. Mouth an elongated slit, outer lip notched at the suture. Imported in large numbers for ornamental and other purposes (Fig. 141 A).

All tropical seas.

Cowries (*Cypraea sp.*).—Oval shells very convex above, flattened below, the opening narrow, extending the whole length of the underside and with a recurved notch at each end, the lips toothed or grooved. The spire is frequently obliterated. Surface in tropical species highly polished, variable in colour. Imported largely for ornamental and other purposes (Fig. 142 A).

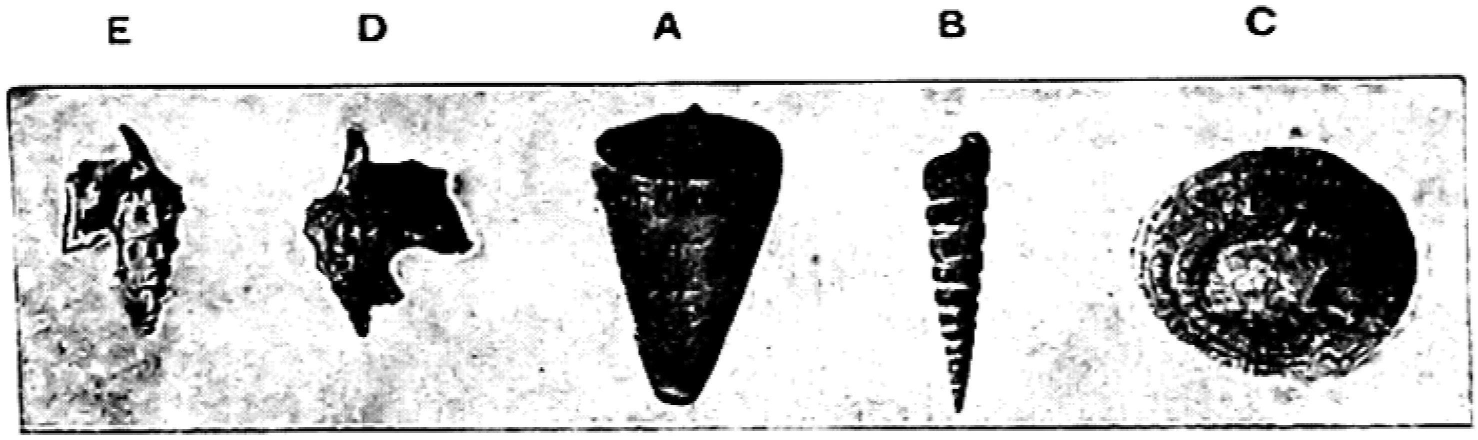

Fig. 141.—A, Cone Shell (*Conus* ; B, Tower Shell (*Turritella*); C, Limpet (*Patella*) D, Pelican's foot (*Aporrhais*) from above; E, Pelican's foot from below.

C. europaea has numerous transverse grooves—spire obliterated, lower surface white, the upper grey or purplish grey, with or without three dusky spots. About ⅜ inch long.

Fairly common in some localities along the coast.

Spout Shell, Pelican's Foot (*Aporrhais pes-pelicani*).—Shell with long tapering spire of numerous whorls, knobbed, outer lip of shell spreading outward into ridged lobes suggestive of a webbed foot. Mouth narrow with a short canal in front. Young examples have only a slight expansion of lip. (Fig. 141 D, E.)

Deep water off British coasts. Common.

Tower Shell (*Turritella terebra*).—Shell slender, tapering, may be two inches long and half-inch broad. Whorls convex, numerous, 15-20, and ridged. Colour variable, white or light reddish (Fig. 141 B).

Deep water off coast, frequently cast up on beaches.

Periwinkle (*Littorina littorae*).—A small shell, conical, thick, with whorls convex showing longitudinal striae. Mouth round, even, with sharp edge. Colour of shell dark greenish.

Common on all rocky coasts.

"The Silver Tommy"—Pyramid Shells (*Trochus sp.*).—Shell pyramidal, nearly flat at the base. Whorls numerous, sometimes flat, variously marked, sometimes worn exposing iridescent silvery layer. Mouth oblique showing pearly within. Animal vegetarian.

Common amongst sea-weed and in pools left by the tide.

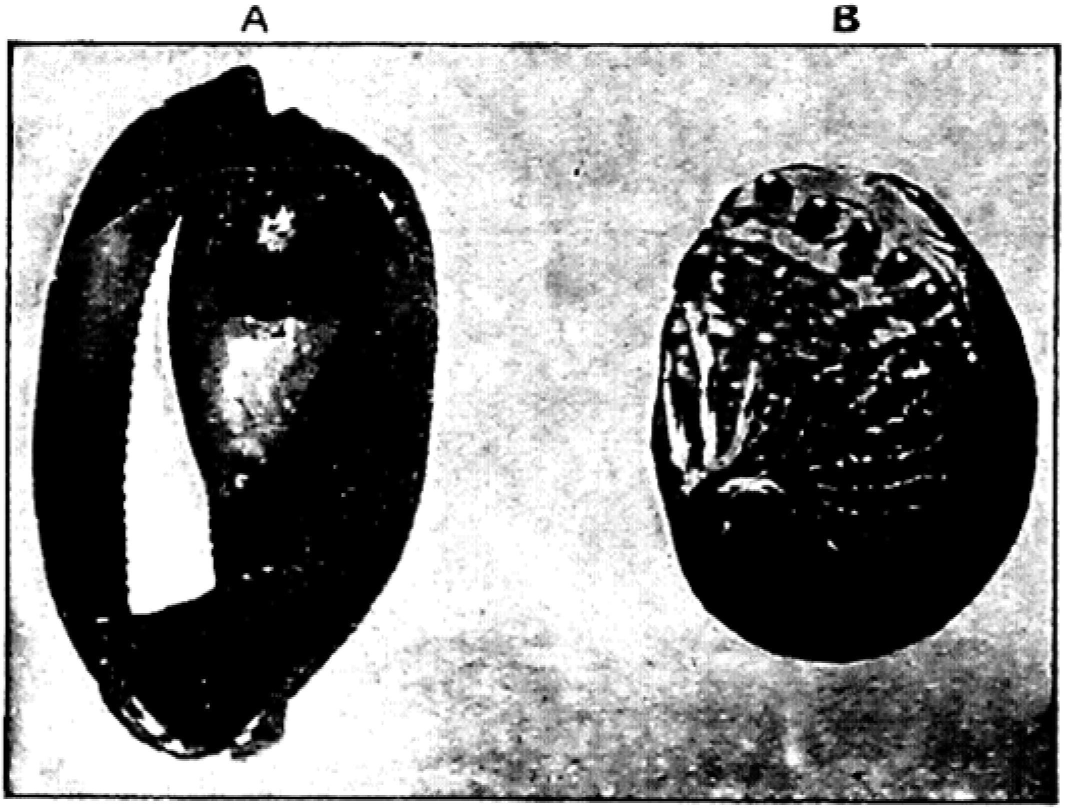

Fig 142 —A, Cowrie (*Cypraea*) opened to show concealed spirals.
B, Ear Shell (*Haliotis*).

The Ear Shell (*Haliotis sp.*).—Shell ear-shaped with low depressed spire, laterally placed, open internally. Outer surface rough with curved striations, perforated by a series of holes placed nearly parallel to the margin. Inner surface highly iridescent. Mouth very large (Fig. 142 B).

Abundant on shores of Channel Islands.

The Limpet (*Patella vulgaris*).—Shell conical, with apex nearer the anterior end. The surface radiated with ribs from apex and crossed by concentric striae. Dusky green in colour, but variable. 1½ inches or more in length.

Abundant on all rocky coasts.

The Pellucid Limpet (*Helcion pellucidum*).—Shell thin, helmet-like, apex well forward, brownish with delicate radiating blue lines.

Found on sea-weed fronds near low water mark.

The Tortoise-shell Limpet (*Acmaea testudinalis*).—Shell conical, limpet-like, smaller than patella, thinner. Outer surface brown and white, mapped out in regular areas. Inner surface brownish at apex, succeeded by pale band of bluish white. Margin with brown and white alternating marks.

Low water to 30 fathoms.

Common Tooth-Shell (*Dentalium entalis*).—Shell tubular, elongated, slightly curved, tapering, with a small slit in the margin at the narrow end. White and glossy externally. Length up to 2 inches breadth nearly $\frac{1}{6}$ inch. Entire shells rare, mostly broken at the tip.

Common in deep water. Rarely found with the animal, but often containing a Sipunculid Worm.

The Mailed Limpet—The Canoe Shell (*Chiton sp.*).—Shell of eight transverse, overlapping, narrow, slightly keeled plates, lodged in and surrounded by conchin layer of leathery texture. Margin either naked or covered with hairs or spines. Animal with flat creeping foot like limpet.

Very abundant on rocks at low water.

Bubble Shells (*Bulla sp.*).—Ovoid shells with spiral concealed. Apex at end of narrow tube on top of shell—aperture longer than the shell and rounded at each end, lip sharp.

In all temperate and tropical seas, especially on sandy bottoms.

FRESH WATER.

Mud Shells (*Lymnaea sp.*).—These are delicate shells with tapering pointed spire, brownish, greenish, or pale in colour. The form varies a good deal in the different species. The animal inhabits ditches, wet fields, stagnant water or slow moving streams, sometimes crawling on the underside of the surface film. It may be recognised by its short, broadly conical horns.

Fresh-water Bubble Shell (*Physa fontinalis*).—Shell small, about $\frac{1}{3}$ inch long, oval, thin, spire short, the last turn large, mouth oval, *spiral left-handed.*

Animal occurs on pond weeds upon which it feeds. The body is yellowish white, semi-transparent. Tentacles slender, with eyes black on the inner side of the base.

Lid Shell—The Fresh-water Limpet (*Ancylus fluviatilis*).—Shell helmet-shaped with recurved tip, delicate, translucent, pale yellowish grey or brownish. Mouth oval, inside glossy, whitish. One quarter inch long.

Abundant in streams on stones and aquatic plants.

Coil Shells, Ram's Horn Shell (*Planorbis sp.*).—Shell flat, coiled in one plane or nearly so. Outline of shell nearly circular; the mouth is rounded or squarish. Mostly small species inhabiting still or running water, adherent to plants.

P. corneus, a large form about 1 inch in diameter.

Marsh Shell (*Paludina vivipara*).—Shell roughly conical, with very convex turns to the spire, which is rather truncated at top. Mouth roundish, with thin lip folded back on inner edge. Colour greenish, with three brown bands on lowest whorl, two apparent upon the upper turns. Transversely striated.

Marshy places and slow moving streams.

Animal a gill-breather and viviparous.

LESSON LVI.

THE EARTHWORM.

[The teacher should have some worms in a box or flower-pot, a piece of glass to act as a cover, and a hand magnifier or pocket lens.]

Behaviour.—We have here some worms which I shall place upon the top of some loose earth in a flower-pot. I shall cover the mouth of the flower-pot with a piece of glass. We shall keep the worms in the light for a little and meantime watch their behaviour. Observe how easily and freely they move. We see them wriggle and twist and turn and grope about. Now watch one as it moves along. You may take one out of the flower-pot and allow it to crawl upon the table.

Try to discover the **way in which crawling is done.** Look at the front end—what happens there? First of all this end is stretched out very long and thin. Then it is shortened and thickened. This stretching and then shortening is really taking place all along the body, but it is seen most clearly at the tip, which can be made thinner than the rest. The result of this lengthening and shortening of all the parts of the body is that the worm moves forward. The parts which produce movement are **muscles,** and this changing of shape is called "contraction" or "drawing together." The outer wall of the worm's body consists very largely of muscles, and by means of these it pushes its way through the soil.

Keep on watching the worms in the flower-pot. Do you see any going down out of sight? Yes, most of them sooner or later **force their way below ground.** How do they manage? Just by the same kind of movements as we see them crawling by above the ground. Notice how they insert the finely stretched-out tip of the body between the particles of soil. Next, as this part of the body is thickened by the drawing up of the portions within and behind, it acts as a wedge. The soil particles are pushed aside and gradually the worm is able to work its way into the soil out of sight.

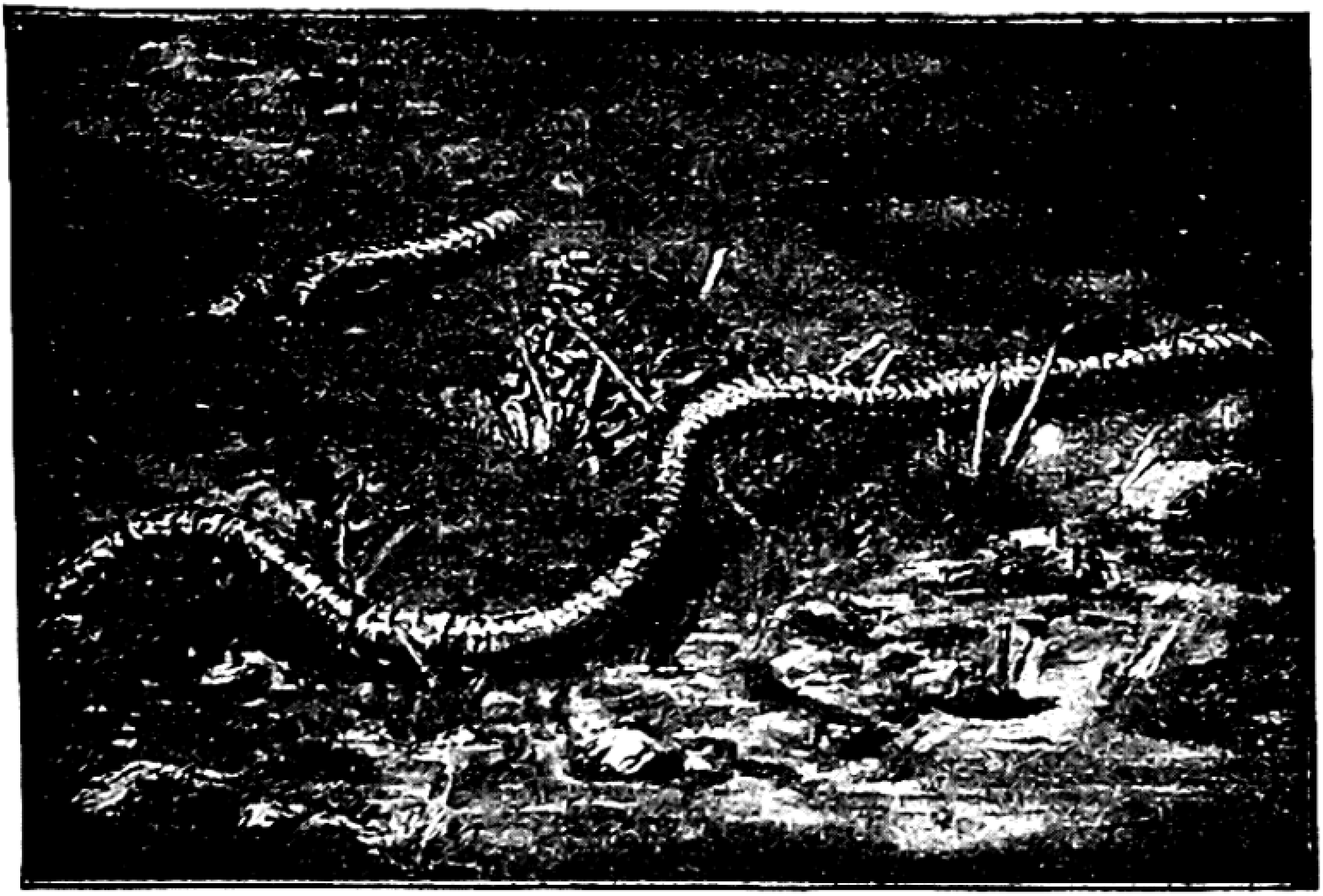

Fig. 143.—The Earthworm.

Why do the worms go below ground so quickly? They are, of course, not at home above ground. Their place is below, where it is dark. But you may ask: how do they know they are not in the dark? Has a worm got eyes? If you examine it ever so carefully you will not find any. Worms have not got eyes, but their **skin is very sensitive to light**—they feel the light. They do not appear to be comfortable in it. Those worms we sometimes see crawling at the surface of the ground in the daylight have either been washed out by the rain or are sick. If you shine the light of a lantern upon worms which are above ground at night you will cause them to enter their burrows.

Bristles.—Now take one of the worms in your hand, and, without hurting it, draw it gently through the tips of your fingers. Is the body quite smooth? No. What do you feel? There appear to be two rows along the body near its lower side which are rougher than any other part. This roughness is caused by very fine stiff bristles which stick out along these rows. We cannot see them well without a lens, but there are really four rows, two on each side, set closely together.

Of what use are these bristles? Have you ever tried to draw a worm out of the ground, or watched a bird attempting the same thing? If so, you know how the **worm can grip the ground.** It uses the bristles to grip the soil as it makes its way through it, and to dig them into the sides of its burrow when you try to pull it out. When we know this and also remember that it can thicken its body and make it quite tight in the burrow, we are not surprised that the blackbird has to pull very hard to drag it out of the earth. Indeed, the worm often grips so firmly that it is broken in two in the struggle.

The bird, of course, eats its share. But the wonderful thing is that the part left in the earth does not always die. There grows upon it a piece exactly like the bit which the bird ate. A tail-end grows a head-part, and a head-part a tail-end. What happens, then, when the gardener accidentally cuts one with his spade? If the worm was well and strong at the time, it is likely that two worms will result. Remember that this should never be done wilfully, *since the worm feels.*

Sometimes a more wonderful thing happens. I once saw a worm injured by a spade; its body was torn at the side, but not cut in two. At the broken part a new tail grew, so that it had three ends. It lived a long time, though it could not move very freely. It dragged its tails behind it.

The Work of the Earthworm.—What do the worms do below ground? We have seen that they can **make burrows** for themselves by pushing the earth aside. Wherever they go, air and rain follow. The air and the rain change the soil in such a way that plants can feed more easily upon it. This is why the farmer turns over or ploughs the soil. Where there are many worms, therefore, the soil is made better for plant-life.

While they are burrowing they **swallow large quantities of earth.** Their bodies are long slender tubes surrounding an inner narrower tube, which is open at both ends. The outer one does the moving and feeling, and the inner is used for feeding. The earth taken into the body is passed along the inner tube, being first grasped by a lip which hangs down at the very tip in front, and acts like a finger. You should look for this small "finger" on a good-sized worm.

Amongst the earth swallowed there are little bits of decaying plants, and this is the food of the worm. The rest is passed on, and leaves the body as "castings." You may see these on a lawn or garden-path in the early morning. Or you may have noticed those of the sand-worm, whose habits are similar, on the seashore. They are left on the surface by the earthworm, so that you see this creature not only lets the air down into the soil, but also **brings the soil up** to it. But this is not all. In the same manner as the soil is altered by the air and rain, it is changed by juices in the worm's body. Many of the little bits of soil, too, are ground down in a gizzard which forms part of the inner tube, and made so much smaller and finer that they become very useful to plants.

You should make some drawings of earthworms boring into the ground, and creeping along the surface.

Can you name any common enemies of the earthworm?

The teacher who is so inclined might do some simple experimental work with the feeding of earthworms kept in soil in large flowerpots. He cannot do better than follow the method of work described in *Vegetable Mould and Earthworms* by Charles Darwin.

LESSON LVII.

OWLS.

[There are no fewer than nine owls reckoned as British, but of these only four are at all common. It is to these four that the following remarks apply. The lesson may be taught in places where owls are known, *i.e.* in most country districts. In town schools, where the same appeal cannot be made to the pupils' experience, a stuffed bird, or in a rare case, a living captive will be necessary for effective instruction. If a visit to a museum can be conveniently arranged where owls may be seen, this should be done.]

General Appearance.—Owls have various peculiarities distinguishing them from other birds. Let us see if we can make out clearly what these are. First of all, are they not distinctive in their general appearance? What is the appearance of an owl? Let us look at the one in front of us. This is a bird with a heavy-looking body and a large broad head, with a somewhat flat face and large eyes. The neck seems absent, and this feature gives the bird a heavy and clumsy look in marked contrast to the usual appearance of birds in whom a rather long and graceful neck is common. The feet are stout and feathered to the toes, which have very strong and sharp claws. We shall look at all these things more closely later on; meantime let us go on to enumerate some other things which mark out owls as peculiar birds.

Flight.—After the appearance of the owl, what do we think of next? If you have at times been near an owl as it flew, you must have noticed its peculiarly silent flight. The feathers are singularly soft, as you can feel here, and when the bird flies we realise a second peculiarity of owls, viz. their almost **silent** flight.

When Abroad.—Talking of the flying of the owl makes us think of the time at which it flies. And here we must notice that there are day owls, *e.g.* the snowy day owl—not at all common in Britain—as well as night owls. But we have only four really common owls in our country, and they are all birds of the night.* That does not mean that they may not be seen during the day. Sometimes they are, and may even be seen feeding then, but for all that our common owls are creatures of the night, hunting their prey after dusk, and hiding in holes in trees, in old towers, barns, and other dark places during the day. Notice that this is quite an **unusual habit** amongst birds.

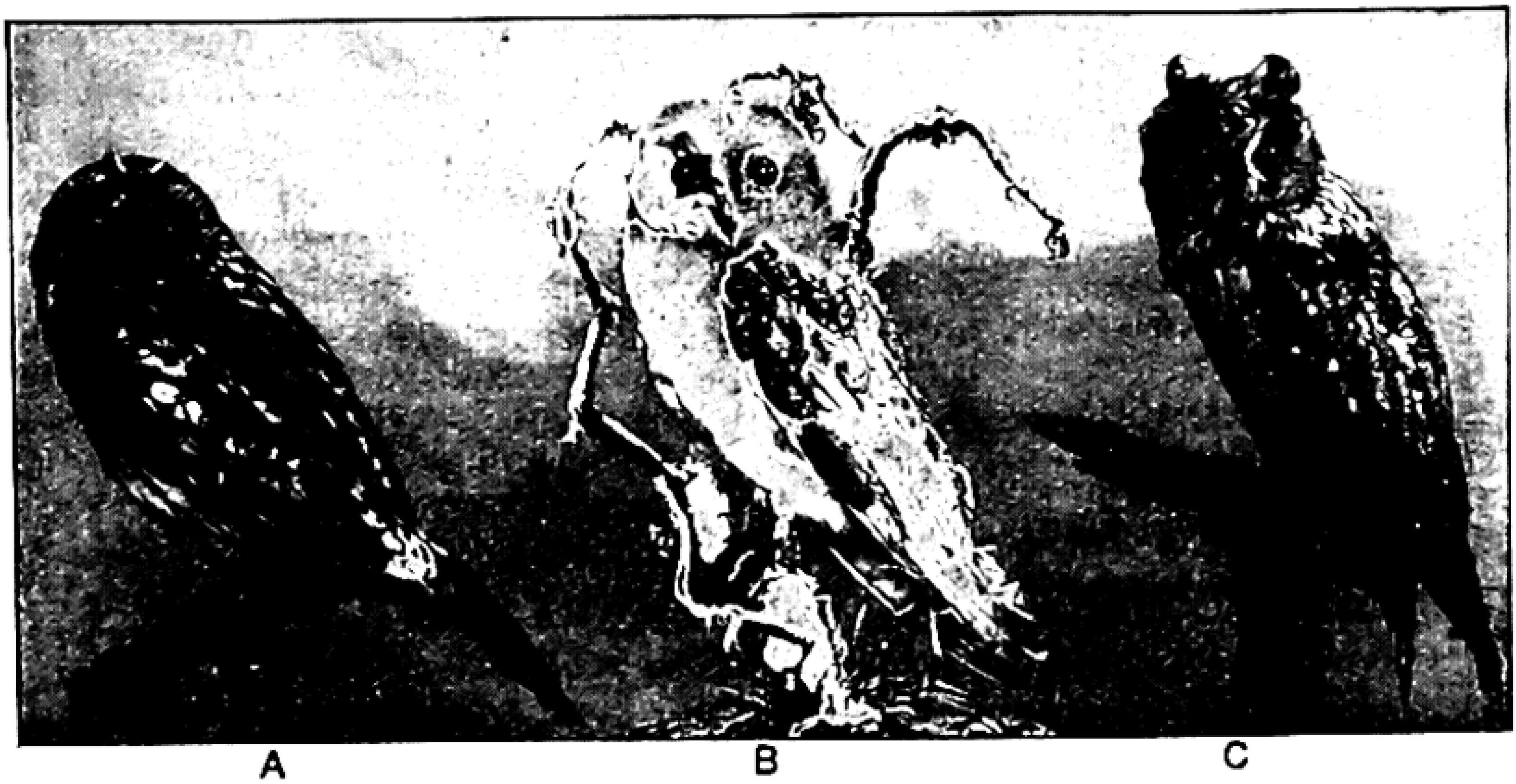

Fig. 144.—A, Short-eared Owl; B, Barn Owl; C, Long-eared Owl.

Voice.—A fourth peculiarity about owls is their voice. They differ from other birds in making very unbird-like sounds, although it is a mistake to think, as some people do, that owls all make the same kind of noise. Of our four owls only two seem to be given to making sounds to any extent. Our commonest owl in Britain is the so-called **barn or church owl,** which utters a harsh shriek. It is also called the screech owl on account of its voice. It also makes a noise resembling snoring. The **tawny owl** is the bird whose "hoot" is familiar to most of us, and which, although some people think it weird and uncanny, I am sure boys and girls like to hear. Most boys know the trick of hooting through the two hands held together so as to form a kind of box covered by the two thumbs placed alongside each other, and inducing replies by the owls. You must read Wordsworth's description of the boy who did this.

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* The short-eared owl is to a considerable extent a day bird.

> "Many a time,
> At evening . . . .
> . . . . would he stand alone
> Beneath the trees or by the glimmering lake ;
> And there, with fingers interwoven, both hands
> Pressed closely palm to palm and to his mouth
> Uplifted, he, as through an instrument,
> Blew mimic hootings to the silent owls,
> That they might answer him—and they would shout
> Across the watery vale, and shout again
> Responsive to his call,—with quivering peals
> And long halloos, and screams and echoes loud,
> Redoubled and redoubled : concourse wild
> Of jocund din."

The young tawny owl makes a curious clacking or **snapping** sound, but does not hoot.

The **long-eared owl,** also a common bird, is rather silent, and only occasionally makes a clacking kind of sound.

Food.—What kind of food do owls get at dusk? Small animals such as mice, rats, voles, moles, bats, small birds, beetles, and such like. They are hunters very largely of the class of animals which we call vermin and are thus very useful birds.

Plumage.—Now I think we might look once more at the owl itself, remembering the kind of life it leads. Have you felt the owl's plumage? It is very soft and fluffy.

The bird is not so bulky as it looks. The wings you will find if you look at them are large and curved, so also is the tail. When the bird flies the softness and looseness of the plumage produce a movement without whirring the air. Hence the silent flight. Do you see the value of this to the owl? It is able to reach its prey without the approach being discovered.

Eyes.—How is the owl able to discover its prey? You have noticed the eyes of the owl. Firstly they are very large. Owls are sometimes said to be able to see in the dark. Of course they cannot see in complete darkness; no animal can do that. But the pupils (the central openings which admit light to the eye) of their eyes are very large, so that when light is very scanty they can still get enough to see with. They depend on moonlight a good deal. They are so accustomed to seeing in dim light that strong light is unpleasant to them. When a night owl is taken into the light, it closes the pupils as far as it can to shut out the glare.

Their eyes can look forward too, which is a great advantage when the light is dim. The owl's eyes are not fixed to look quite straight in front as ours do, but slope slightly obliquely on the sides of the head. But the bird has the power of moving them slightly so that they can look straight forward or to the side. If you could see an owl without its feathers you would see this clearly. Notice then that, although a hunter in the dark, the owl can see better than most creatures, and its eyes are useful in guiding it towards its prey.

Ears.—Then an owl has a very fine sense of hearing. If you look behind the circles of feathers around the eyes on each side you will find a long open slit leading into quite a roomy space. The owl can move its skin here so as to open the slit quite widely even as it flies. This slit is really the opening into the ear, and no other bird has such a big ear-hole. The owl makes no noise itself, but it can hear the faintest stirring of the animals it hunts. Most birds have splendid hearing powers, but none have a flap around the ear which can be moved to assist it in catching the faintest sounds such as the owl possesses.

Eared Owls.—Two of our common owls are known as eared owls, the **long-eared owl** and the **short-eared owl.** But this name refers to tufts of feathers which these birds have projecting upward above the eyes, and has nothing to do with their hearing.

Beak and Claws.—Owls have a short but very strong **beak.** If you have ever allowed an owl to take hold of your finger you will know how strong and sharp the beak is. You can see how well suited it is for tearing flesh or for breaking small bones. It resembles the bill of the hawks, whose diet is very similar. The owl swallows the fur, feathers, and bones of its prey as well as the flesh, but afterwards it throws up pellets of these substances when they have become separated from the flesh inside its stomach. These pellets are got in large numbers near the nests of owls.

In thinking of the prey of the owl we ought to notice the very strong and sharp claws, which are very useful weapons to the bird. Notice too that the owl sits with two of its toes turned forward and two backward.

Egg.—Have you ever seen an owl's egg? It is white and more rounded in shape than eggs usually are. For example, the egg of the barn owl is about an inch and a half long and about an inch and a quarter broad. The eggs of other owls are not quite so round as this, but still show the rounded shape to some extent.

Distinguish the Four Common Forms.—You can easily distinguish the four owls by their appearance. The **barn owl** is the lightest in colour. It is light reddish yellow above the small black and white spots. The patches around the eyes and the under side of the body are white. The **tawny** or hooting owl is brownish red with dark brown streaks, the lower parts reddish white or yellowish. There are large white spots on the shoulders and wings. The "**eared**" owls are known by the tufts. In the long-eared owl they project about an inch and a half above the head, in the small-eared owl they are much shorter, projecting not more than half an inch (Fig. 144).

You should make an outline sketch of an owl with a mouse or vole in its bill, and write down a list of the important differences between owls and other birds.

LESSON LVIII.

SOME FAMILIAR ANIMALS OF OUR COUNTRY.

[In general our wild Mammalian fauna, which is by no means extensive, is too little appreciated or its life understood. The aim of the following lessons on a few of these is to awaken the interest and to promote the intelligence of the pupils with regard to some of the more familiar wild creatures of our land.

The difficulty with regard to teaching lessons on such subjects, where the possibility of being able to exhibit live specimens is rather remote, may be got over by appealing in the first instance to the personal knowledge of the pupils, and by the relating of personal experiences of the teacher with regard to the animals under consideration. Drawings should be made by the teacher as an accompaniment of the lesson, and further opportunities should always be taken, wherever available, of making visits to museums or zoological gardens, or of conducting rambles to places where wild creatures may possibly be seen. Lastly, it is often possible to see stuffed animals in dealers' shops, and some schools possess objects of this kind. Such material is of undoubted value.]

THE WATER VOLE.

Most of you in the country, at least, have seen the **water vole.** Perhaps you do not know it by that name, but by that of the water rat. It is not, however, a rat, as we shall see. Where do we usually see this animal?

It lives in a burrow, which is generally of considerable depth, by the banks of a stream. We see the creature sometimes scurrying along the water's edge, diving and swimming in the stream. Unless we come on it quietly without disturbing it, we do not get much opportunity of seeing what it is really like. Have you ever had any exciting experiences with it? Those boys who practise the art of catching trout in small streams by lying on the bank and passing the hands beneath the trout in hiding sometimes unawares startle or even lay hold of this generally dreaded but comparatively **harmless** animal. Boys mostly dislike the creature, thinking of it as a rat, and sometimes ignorantly and foolishly hunt it when they discover it in this way.

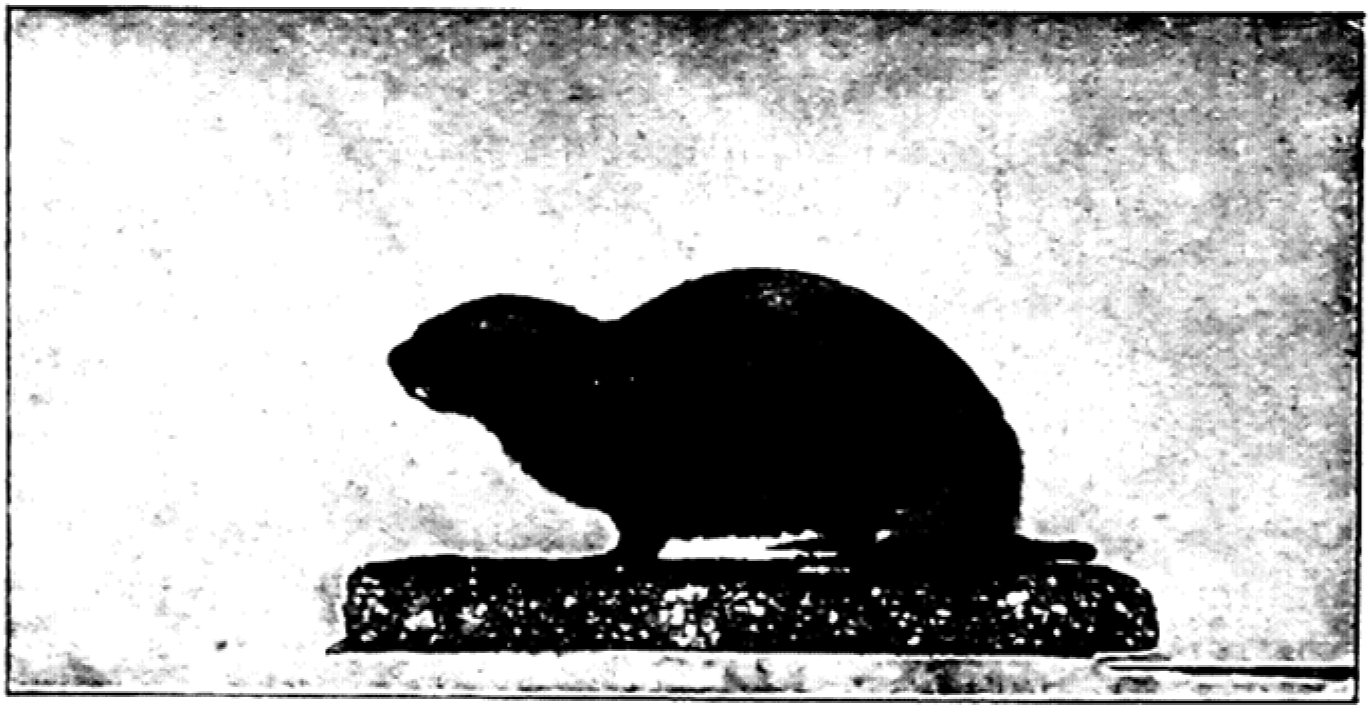

Fig. 145.—The Water Vole. Note the blunt snout, curved incisor teeth, depressed ears, thick neck, short legs and tail. Compare with rat, p. 334.

Let us try to understand its life. But first of all we shall describe the animal, because so often we get only a momentary glimpse of it. I hope your teacher will be able to show you the things of which I shall speak.

Its Appearance.—The water vole is a small furred creature about the size of a rat, but **bulkier** in build. This feature of it strikes us at once when we see it. Its fur is smooth and glossy, thick, reddish brown, mixed with grey above, greyish underneath. But in some districts, such as the one in which I write, a blackish variety occurs, equally common. The **head** differs in shape from that of the rat. It is somewhat flat above, broad, with a **blunt snout.** The eyes are black, the nose is small, and the sensory hairs ("whiskers") are short and scanty. The teeth in front of the mouth are yellowish, curved, and have sharp chisel-like edges.

On first view the water vole looks as if it had no **external ears.** These are present, however, and of fair size. But they lie quite flat against the head, and the fur around them covers them completely. Try to remember this, and be sure and verify it on a specimen, when you can.

Another marked feature is the **thickness of the neck.** The water vole's neck is nearly as thick as its body.

Its legs are short, its feet are slender and have sharp claws.

It has a short tail, scantily furred, about half the length of the body (Fig. 145).

Along with your teacher make a drawing of the water vole.

The Life of the Water Vole.—Now let us consider its life.

What is the relation of this creature to its surroundings? With its slender sharp claws it **scrapes tunnels** and passages in the banks of streams. In loosening the earth you can easily understand how it will in this way share in the gradual loosening and breaking down of the banks. But as their numbers are only occasionally great, the damage done is not generally serious.

What use does it make of its strong sharp **chisel-edged teeth?** It **gnaws** all kinds of roots and stems growing near the water. This may include grasses, grain, trees, and shrubs, as well as purely aquatic plants. The teeth are adapted for such diet, although the water vole appears to take as food the larvae of aquatic insects as well. The water vole, like all rodents, gnaws hard substances without eating them.

What is the meaning of the **flattened ear lobes?** The ear lobes of most terrestrial animals stand out from the head,—compare the rat for example. In animals which spend much of their time in the water swimming and diving an outstanding ear lobe would be a disadvantage, and we find that such animals have this member reduced in size, or otherwise altered, so as to give an even uninterrupted contour to the head, neck, and body. You can see this in water voles, otters, and seals, whilst in those mammals which are entirely aquatic the lobe is completely absent.

From this short summary of a water vole's habits do you think it is a creature either to fear or to hunt? When you disturb it in the stream it is just as much alarmed as you can be. For all that you must be careful, for there is no doubt but that if you hold on to one it will bite in self-defence if it gets the chance. And, remember, its teeth are exceedingly strong and sharp.

Unless these creatures become very numerous, and the damage they do in destroying banks or devouring farm crops becomes apparent, they should be left alone to add to the charm of the wild life of our streams. There is no proof, as is sometimes stated, that they devour the eggs or fry of fish. Learn from what you have seen and heard to distinguish the water vole at sight from the common rat, which also in places frequents the banks of streams.

Besides the water vole, the teacher may be able to call the attention of pupils to **land voles**, which in some districts are very common. Of these, there are two species in Britain, the field vole (*Microtus agrestis*) and the red or bank vole (*Evotomys glareolus*). Voles are sometimes very destructive to field crops. Information as to their habits, enemies, and other features will be found in Leaflets on Wild Animals, Birds, etc., issued by the Board of Agriculture and Fisheries—Price, One Penny.

LESSON LIX.

SOME FAMILIAR ANIMALS OF OUR COUNTRY (*continued*).

RATS AND THEIR RELATIONS.

The rat is familiar to us all as one of the least attractive of living creatures. We have good grounds for disliking this somewhat remarkable animal. Yet there are facts of great interest in connection with it which we shall be the better of knowing, and to know which will help us to understand its life and habits.

Peculiarities of Rodents.—Of all the animals upon the earth with hairy coats (mammals) the largest and most important group is that of the Gnawers (**Rodentia**). This group is also the most widely distributed upon the face of the earth; it includes squirrels, beavers, voles, hares, rabbits, and also rats, mice, and many other forms. They are distinguished from other animals by their teeth. Have you noticed the front teeth in the mouths of any of these animals? They are curved, are very hard upon their outer surface, have a sharp edge like a chisel, and have the striking peculiarity that they **keep on growing** throughout life. As a consequence of this last feature, such animals require to continually gnaw at hard substances—wood, bark, roots, and such like to keep the teeth down to the proper size. This is one of the causes which make these animals so destructive.

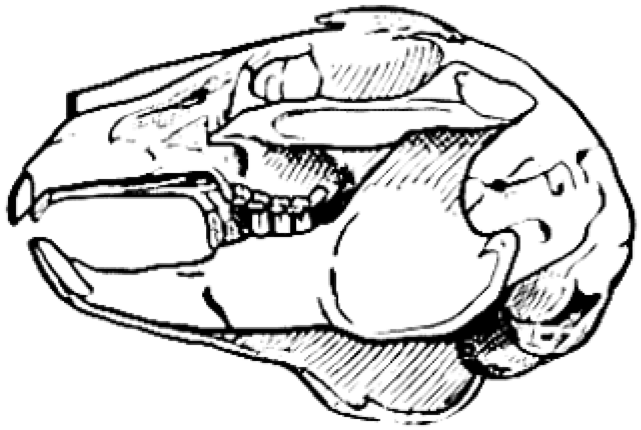

Fig. 146.—Skull of the Rabbit.

Note the curved chisel-edged incisor teeth in front. Observe also the gap between these and the flat bruising back teeth. This gap fills with loose skin from the side of the mouth when the rodent is merely gnawing to keep its teeth in order. This prevents the gnawed fragments going down the throat.

You must take the first opportunity you get of examining the teeth of a rabbit, squirrel, mouse, or rat, so that you may see their distinctive shape. Perhaps you have already noted these upon the water vole (Fig. 146).

Of all the gnawers the Family of the **rats and mice** contains the largest number of different kinds (*species*), showing us that there is great diversity amongst them.

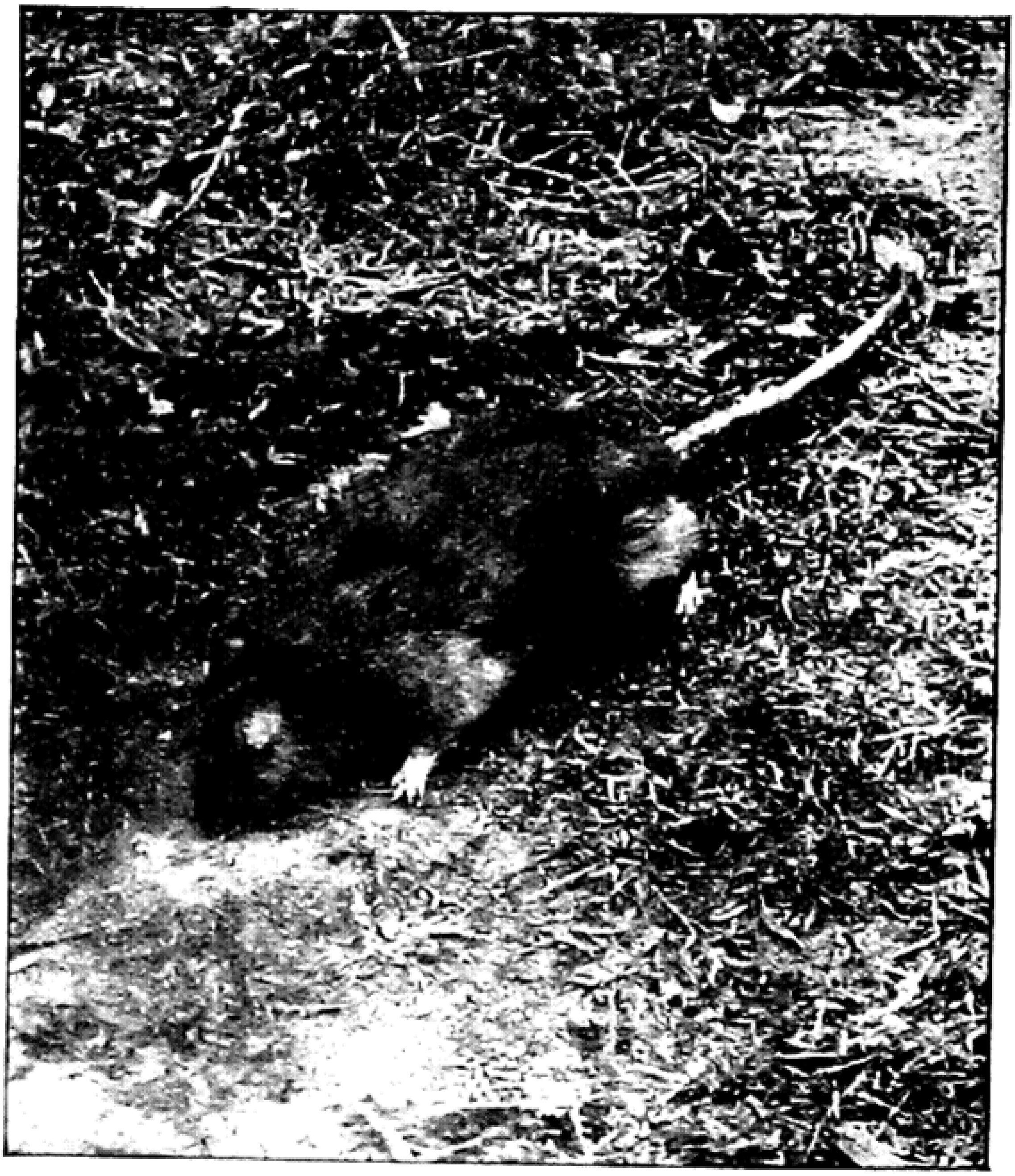

Fig. 147.—The Brown Rat.

Note the large ears and long tail. The tapering snout is not well seen in this view. Compare with figure of Water Vole (p. 330).

Do you know how many kinds of rats and mice we have in our land? Not a great many. There is the common brown rat, which is very abundant; the black rat, which is very scarce; the common or house mouse; the long-tailed or wood mouse; and the harvest mouse. Of these the only formidable creature is the brown rat (Fig. 147).

The Common or Brown Rat.—Let us note the qualities about this animal which make it justly disliked by us. You must write these down.

1. **Its Haunts.** The places it frequently lives in, such as sewers, drains, outhouses, dirty river banks, holes in stables or barns, mostly repel us.

2. Then its feeding is often not very clean—dieting on garbage of all kinds, while at the same time it may steal and destroy grain and other produce in very great amount.

3. Its gnawing habits render it very destructive to woodwork, sacks of grain, and many other kinds of property.

4. It is an agent, in the East especially, in transmitting plague and other diseases to mankind.

We have good reason to dislike the rat. And more especially because there are not only all the bad qualities of the individual rat but also of the great company of them, for their numbers are very large. Although enormous numbers are continually being trapped and killed in various ways, they remain as abundant as ever, so that the loss incurred by their feeding and destructiveness, more especially in warehouses and on farms, amounts to many million pounds every year in Great Britain alone.

It is not generally known that of all the wild animals living in our land the brown rat, so far from being a native animal, introduced itself, travelling from the East in ships, less than 200 years ago. For about 300 years before that the **black rat** was the only one in our land, and it also was introduced. All our other wild animals have been here from before the time that man himself first inhabited these islands.

The brown rat has spread until it is now found in every quarter of the globe. In this country it has taken the place of the black rat—fighting it, killing it, or driving it away, so that it is now extremely scarce. It is usually very difficult for a new animal to establish itself in a new land, but the brown rat has been most successful wherever it has gone in being able to find a home and to increase in numbers.

The Rat's Success.—Although we do not like the rat, we can see that it has qualities which make it as an animal highly successful. I think you should write down what these are, because they give us the clue to the problem of the rat.

1. Rats can live upon many different kinds of food, often upon food which few other animals will take. They are thus not easily starved. In the end they will eat each other rather than starve.

2. Their numbers increase rapidly. Even when they are killed in large numbers, it is not long until there are as many as ever.

3. They are very intelligent and clever animals, keen-scented and alert, and can find food in difficult places, avoid traps and enemies. They defend themselves fiercely when they get a chance.

4. They can adapt themselves to all sorts of conditions and climates. When their numbers have become too great in a country they have spread to others. They appear to be able to thrive well in any land.

These are the things which make the rat such a difficult animal to get rid of.

(The teacher might here read the "Pied Piper of Hamelin" with the pupils.)

The Black Rat.—Have you ever seen the black rat? It is a much more attractive-looking creature. It is smaller than the brown rat, being about seven inches long. It is of a **bluish black** colour above, lighter on the under side. Its eyes are bright and blackish, the ears large, and the tail slender, slightly longer than the body.

White Rats.—Most boys are familiar with **white rats.** These are not a third kind of rat, but are simply a **variety of the brown rat** without colouring matter in the surface parts of the body. This variety has been tamed and bred as pets. Many other kinds of creatures show occasional varieties of this kind. There are, for example, besides white rats and mice, white rabbits, white elephants, white crows, white swallows, white men and women, and even, amongst these, white niggers. This kind of animal or person is known as an **albino.**

The House Mouse.—We are all familiar with the **house mouse.** How many of you could describe one?

Fully grown, it is slightly over three inches long apart from the tail, which is little short of the length of head and body. It is of a brownish ash colour above, light ash colour below. The ears are about half the length of the head, the snout tapers, the whiskers are long, and the eyes small.

Field Mouse.—Compare this with the wood mouse, called the **long-tailed field mouse.** It is reddish brown above, whitish beneath, with a light-brownish spot on the breast; the head is long and raised, the whiskers are very long, and the eyes and ears larger than in the house mouse. The tail is nearly as long as the body, which is about 3½ inches long. It is common in cornfields, and lives chiefly on grain, of which it stores a supply below ground for winter use.

Harvest Mouse.—The harvest mouse has several interesting features.

1. It is the second smallest of our British mammals. the lesser shrew being the smallest. It is about 2½ inches long.

2. It constructs a neat little spherical nest of straw attached to a few stalks of corn, wheat, or to a thistle-head, in which it rears its young.

The fur of the harvest mouse is reddish brown above and pure white below, the two colours being separated by a sharp line.

It is common only in the south of England, more or less rare in other parts.

Another familiar rodent of interest is the **Squirrel** (*Sciurus leucourus*). Its habits, which are well known (p. 396), might be revised. The points of interest in the structure of the squirrel to which attention should specially be called, are—

Its fur, reddish in summer, darker and thicker in winter.

Its ear tufts, absent in summer.

Its thick bushy tail—an adaptation to the arboreal habit—a balancing organ, as well as a warmth-giving one.

Its sharp claws, enabling it to grasp well and to hold its food firmly.

Its strong gnawing teeth—(cf. above) useful in breaking nuts.

Get the pupils to draw a squirrel.

If the teacher has any difficulty in giving lessons on the foregoing for lack of material, a visit with the pupils might be paid beforehand to a museum where most of the animals named may be seen. Or the teacher might give the foregoing notes in the course of the visit whilst the animals are under examination. The facts could then be revised subsequently in school, or made the subject of an essay by the pupils.

LESSON LX.

SOME FAMILIAR ANIMALS OF OUR COUNTRY (continued).

A BAT.

[The lesson may be given when bats are still to be seen flying about, or when a specimen has been caught.

There are twelve species of bats occurring in the British Isles, and at least two others are reputed to have been found here. All the bats of this country are insect feeders, but the larger species occurring in tropical regions, such as India and Madagascar, are fruit eating. Bats are for the most part nocturnal or twilight animals; they hibernate usually in large companies in church towers, old ruins, and other deserted places, generally hanging by the feet with head turned downwards. Their sleep is deep, and they often die if awakened out of it. They sometimes waken and fly abroad in mild weather, but this does not appear to happen often.]

Examination and Description.—I have here a long-eared bat (Fig. 148). It is one of the commoner species, let us examine it.

What is a bat? This is our first question. A live bat held in the hand is felt to be a warm-bodied, furry animal. We know that they bring forth their young and suckle them with milk. Bats are therefore mammals. Zoologists place them in an Order of mammals to which the name Cheiroptera is given (Cheir, hand; Pteron, wing). They are mammals whose **hands and arms are adapted to serve as wings.** (That is to say we must think of them as four-footed land animals whose fore limbs have been transformed to serve a new purpose, viz. flying.)

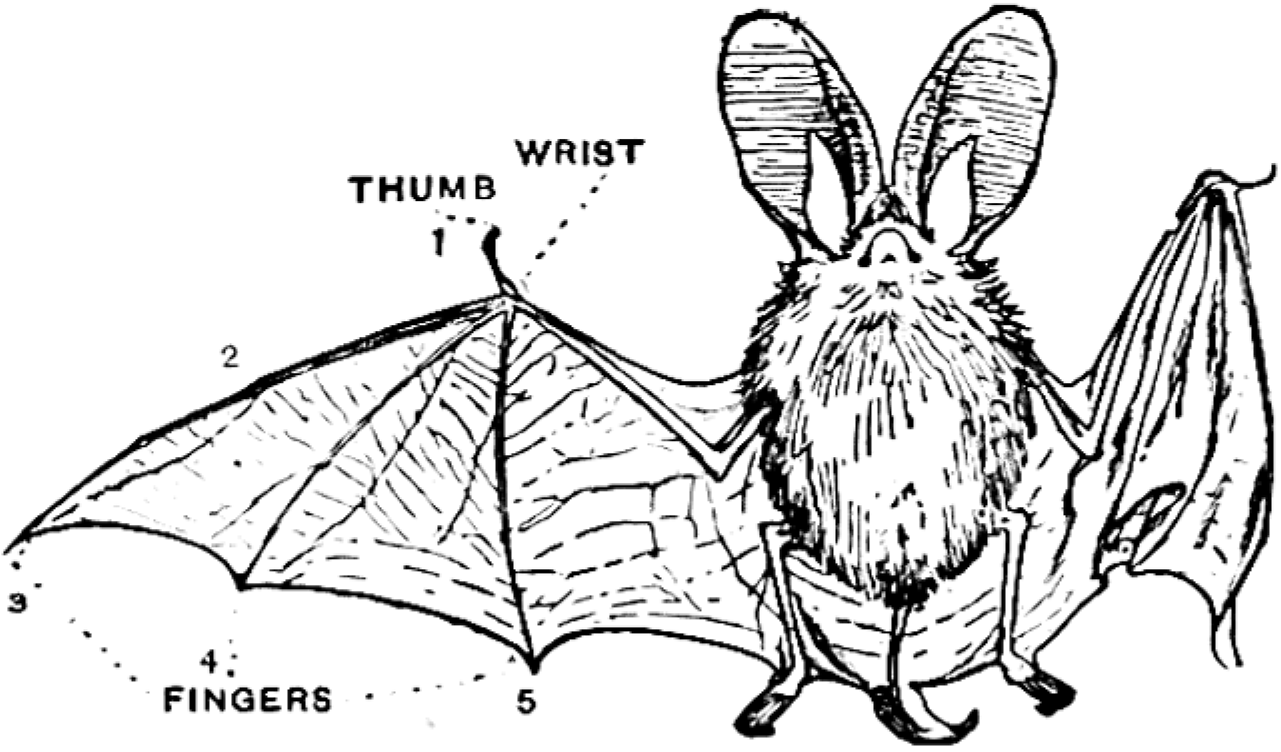

Fig. 148.—The Long-eared bat (*Plecotus auritus*).

This bat, you observe, has extraordinarily long ears, thin, translucent, and folded. They are extremely delicate and sensitive structures. No doubt its hearing is extremely acute. Bats are great moth hunters, and it is quite possible they may detect the sound of the fluttering of the moth's wings. Some bats have folds upon their noses (nose-leaved bats) greatly resembling in structure the ears of the long-eared bat, and these are highly sensitive. So also the membrane of the ears probably serves a similar purpose.

The most remarkable structure about the bat, however, is undoubtedly the **flying apparatus.** Let us unfold the so-called "wing." Notice its remarkable delicacy. Touch it and feel how exquisitely soft it is, observe how it is folded in innumerable creases, this flying membrane stretched between the bones of the hand, arm, and leg. Observe also a similar membrane stretching between the legs and tail. These membranes are so extraordinarily sensitive that they are sufficient to guide the bat clear of obstacles, apart from sight. So much is this the case that bats are said to have a sixth sense. We have often seen how well they fly, guiding their movements with great skill, steering themselves by the tail and its membrane. Remember that they fly in the twilight of morning and evening. Observe too how small their eyes are.

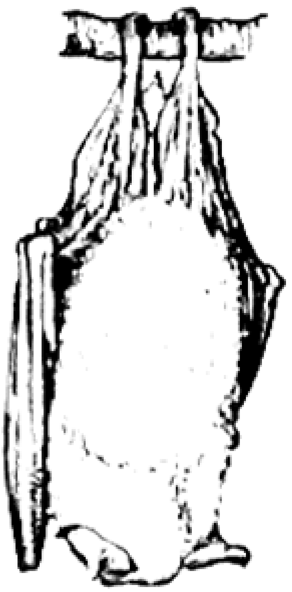

Fig. 149.—The Bat at rest.

Note the large spread of these membranes. Observe that the length of this bat's head and body is less than two inches, and if we add the tail it is three and a half inches. But the wing extent from tip to tip is ten inches. The great area of wing surface is brought about by the **lengthening of the bones** of the arm and fingers, which serve as supports or act as a kind of framework upon which the flying membrane is stretched. The proportions are similar in other bats. Notice that four of the fingers are involved as well as the arm bones. And the membrane stretches across the inner bend at the elbow, just as the skin is stretched in the same place in a bird's wing.

The membrane serves not only as an organ of flight, and as a sensory apparatus (touch), and something more, but is used as a wrap or mantle in which the bat sleeps, and in which the female holds and shelters her young. And some bats use the membrane between the hind limbs as a kind of sac into which they strike the moths during flight. The bat's thumb is free, and carries a strong claw. It is used in walking and in climbing, and proves serviceable also when bats fight, as they not uncommonly do. How does the bat dispose of its wings when walking? They are folded up quite closely and lie against the side of the body. The bat is not good at walking.

There are five toes in the hind foot; observe that they are all of the same length, and have sharp claws, bent like hooks. The bat suspends itself by these when it goes to sleep or hibernates (Fig. 149). The hind limbs are not of much use except to suspend the animal at rest.

Draw a wing and a hind foot. Endeavour to name the different parts observed upon the outstretched wing—upper arm, lower arm, wrist, 1st, 2nd, 3rd, 4th, 5th fingers. (Figs. 148, 150.)

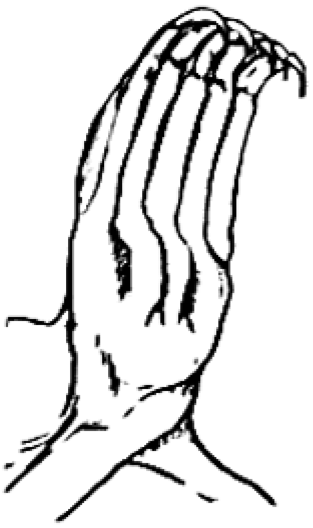

Fig. 150.—The Bat's foot, showing the toes of equal length and with long claws, by means of which the animal suspends itself when sleeping.

Hibernation.—Why do bats hibernate? Think, for example, of the nature of their food, and you should be able to answer this question. Flying insects are extremely scarce in winter. Bats could never find sufficient food to keep themselves alive if they remained awake and active. For this reason, in part at any rate, they hibernate. (A fuller consideration of hibernation will be found on p. 394.)

ZOOLOGICAL SUMMARY OF AUTUMN ANIMAL STUDIES.

Annelida.

Earthworm (*Lumbricus terrestris* or other species).—The earthworm is a member of the Annelid series of worms, viz. those whose body is made up of a succession of rings or segments. The segments of the body each carry eight bristles, a feature upon which is based its further classification in the sub-division Oligochaeta (few bristles).

The Oligochaeta comprise those Annelid worms which live upon land or in fresh water; the Polychaeta (many-bristled worms) are marine.

Insecta.

Hover-flies.—*Order* Diptera, or two-winged flies. The hover-flies comprise the Family Syrphidae, a large and important group, mostly of attractive appearance and interesting habits. The main points regarding these are given in the text.

Wasps.—The Vespidae belong to the *Order* Hymenoptera, which includes bees, ants, gall-flies, saw-flies, ichneumon-flies. These insects possess two pairs of membranous wings. In most cases (as in the wasps) the fore and hind pairs hook together in flight, so that the two wings of each side beat as one. There is a complete metamorphosis in development. In the wasps the larva is legless but possesses a head, the pupa is free, enclosed in a cell formed by the parent or "nurse." The care of the young and the social life exhibited by wasps, bees, and ants mark these as the most highly developed members of the Order.

Mollusca.

Snails and **Bivalves** are representatives respectively of the divisions of the mollusca known as Gasteropoda and Lamellibranchiata.

Aves.

The **Owls** constitute the Order *Striges* amongst the birds. They form a very well defined group, amongst their more distinctive features being the large head, the anterior or oblique direction of the eyes, large ear openings, full soft plumage with facial disc, soft buoyant flight, and carnivorous diet. *Syrnium aluco*, tawny owl; *Asio otus*, long-eared owl; *Strix flammea*, barn owl; *Asio brachyotus*, short-eared owl.

Mammalia.

Order *Rodentia*: Rats and mice, *Mus* species; water vole, *Microtus amphibius*; field vole, *M. agrestis*; etc.

Order *Cheiroptera*: Long-eared bat, *Plecotus auritus*.

For further information regarding Mammals see references on pp. 449, 459.

QUESTIONS ON CHAPTER VI.

(AUTUMN ANIMAL STUDIES.)

1. Name some distinguishing features of hover-flies. What other insects do they resemble, and what is the advantage of this?

2. Name five peculiarities characteristic of wasps.

3. Give an outline of the life-history of a common wasp.

4. Describe the appearance presented by the sole of a snail's foot during locomotion. Explain what is seen.

5. By what means do snails breathe? Of what general nature is their food; what apparatus have they for dealing with it before it is swallowed?

6. Give some account of the senses of a snail.

7. Name six common bivalve shells. What is the use of the shell and to what parts of the body is it attached?

8. Draw the inside of any common bivalve shell and explain the significance of the principal markings upon it.

9. Draw a common spiral shell and name the various parts.

10. What is the peculiarity of the following shells:—limpet, earshell, *Planorbis*, cowrie, cone?

11. Describe the way in which an earthworm moves. How do earthworms behave with regard to light?

12. Give a short account of the way in which earthworms improve the soil for plants?

13. Name four common owls and state a distinctive feature of each.

14. Write a short note upon (*a*) the general appearance of an owl, (*b*) its flight, (*c*) its feeding habits, (*d*) its eggs.

15. Give a brief description of a water vole, mentioning any features you think are of the nature of adaptations to the life which the creature lives.

16. What peculiarity in the structure of rodents renders them specially destructive animals? Name six common rodents?

17. Give a short account of the disposition and habits of the common rat.

18. Describe the general appearance of the house mouse.

19. What is the nature of the flying apparatus of a bat? Give a short account of how it is made up.

20. Upon what do bats feed? When do they seek their food? How do they pass the winter?

21. Name two features in the structure of squirrels adapting them to an arboreal life.

22. What are the chief changes taking place in the squirrel's coat throughout the year? What meaning do you attach to these?

23. What are the chief differences observable between a common snail, a black slug, and a grey field slug?

24. Name a familiar plant pollinated by the agency of hover flies. What is the name given to the larva of *Eristalis*, and why is it so called?

CHAPTER VII.

PLANT STUDIES IN WINTER.

LESSON LXI.

MUSHROOMS AND TOADSTOOLS.

[The lesson should be given early in winter, when toadstools can be obtained without difficulty.]

General Observations.—We have here a very common kind of plant about which there are some interesting things to learn. Let us look at some of these specimens, taking their parts in an orderly way. First of all, notice the **shape.** It is like a small umbrella, a form quite peculiar to this type amongst plants. Let us draw a toadstool, and while we do so we shall name the different parts. The top of the umbrella we call the **cap** (pileus). From the centre of the under side there is the **stalk.** The stalk rises up from a thick mass of whitish threads thickly matted together (**Mycelium,** spawn) which spreads under the ground (Fig. 151).

The cap has a smooth skin upon its upper side. What is the colour of it? This will depend upon the mushroom or toadstool you are looking at. The common mushroom has a glistening whitish skin. Toadstools are very often lightish in colour, but there are some which are beautifully brown on the top, just like a tempting bun from the baker's shop. Others are a beautiful crimson. We find various colours, but there are no green mushrooms. The absence of green is a very important difference from most plants.

If we peel off a part of the skin or if we break or cut the cap we see it is firm and fleshy within. What do we see on the under side of the cap? A great many thin layers hanging down like the leaves of a book. Notice how they are arranged. Take off the cap from the stalk and draw what you see on the under side. These thin layers of the mushroom are called **gills.** But this name does not mean that they are used for breathing, for they are not, but simply that they resemble the gills of some animals by their shape. What is the use of the gills? I will show you how, by a very pretty experiment, you may find out.

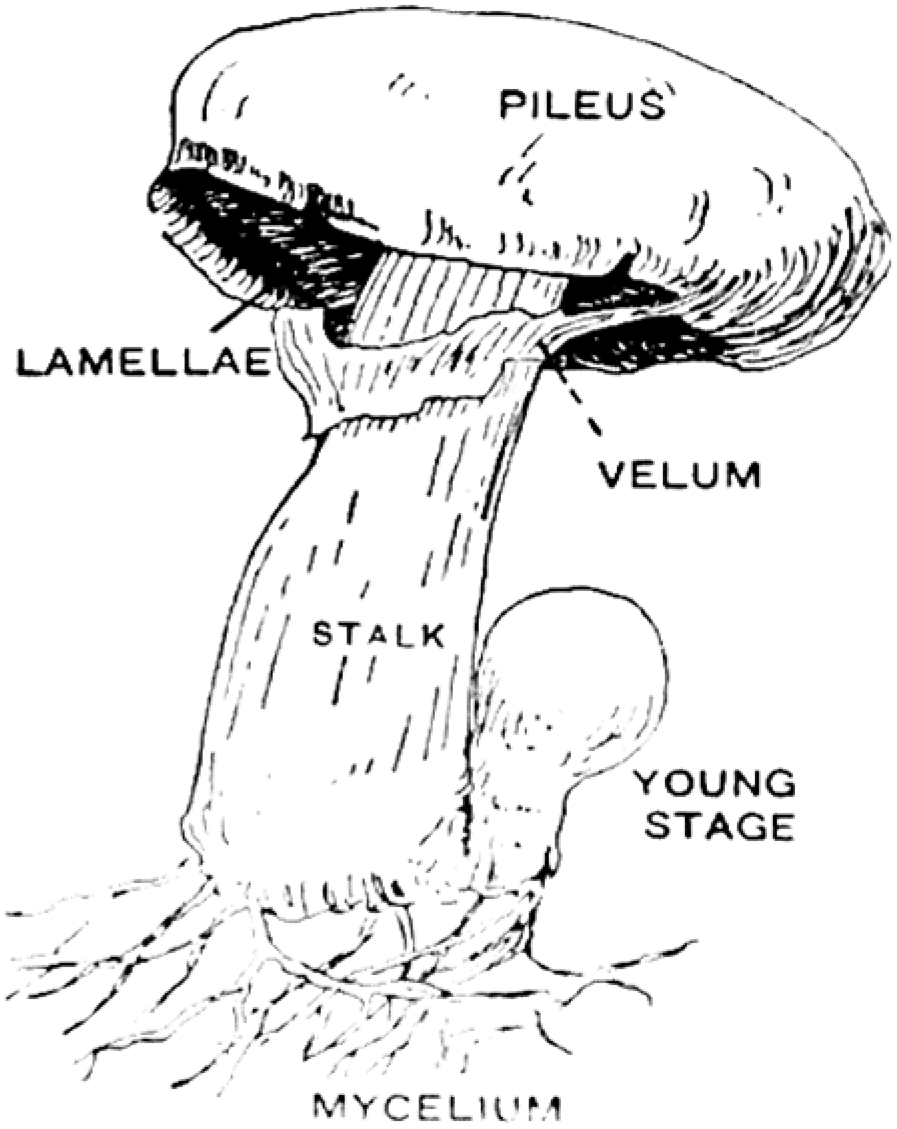

Fig. 151.—The Mushroom. The spores are borne on the lamellæ or gill-like plates below the cap (*Pileus*).

An Exercise.—Take a clean sheet of cartridge paper and place upon it the cap of a ripe mushroom or toadstool overnight. In the morning carefully lift up the cap and you will find traced upon the paper in black or white (depending upon the toadstool) a pattern of the gills upon the cap you have just removed. Look carefully with a lens, and you will see that the pattern is made by very fine dust-like particles which have fallen from the gills during the night. What is this dust? This dust consists of spore-like bodies—**Conidia.**

Reproductive Bodies.—In what type of plant have you seen spores? In ferns. Do you remember what a spore is? It is a reproducing body; from one of these spores a mushroom or toadstool may grow. In what way does it differ from a seed? You remember that a **seed contains a minute plant, but a spore does not.**

If you can see some young mushrooms you find that the gills are not visible, and that the cap is round and knob-like. Compare this with an older mushroom. Besides the exposed "gills" upon the latter what do you find upon the upright stalk? A sort of ring or **frill.** Of course you can tell what this frill is. It is the ragged edge from which the cap tore away as it grew. Many toadstools do not have a frill or ring. This part which tears as the cap of the mushroom grows is known as the **velum.**

There is just one other part we need notice in the structure of a mushroom, and it has been already mentioned. This is the mass of thread-like parts which compose the stalk and which spread in the ground absorbing food. These threads are sometimes described as **"spawn."** This spawn is grown and sold for the purpose of growing mushrooms for food.

Conditions of Growth.—Where do we find mushrooms and toadstools growing? Fields and woods are the usual places. We have already discovered one very important thing about these, viz. that they differ from ordinary plants in **not possessing any green colouring matter** (chlorophyll). Have you learned yet what is the value of the green parts to plants? They make use of the sunlight to break up the gas carbon dioxide in the making of food stuffs. But mushrooms and toadstools do not possess chlorophyll; **they can do without sunlight.** It is not necessary for their growth. When mushrooms are grown artificially, they are grown in the dark.

What is needed for their growth? Three things in particular, viz. **dead vegetable matter, moisture,** and **warmth.** Old pastures and woods where dead vegetation is abundant are therefore suitable grounds for this kind of plant. The mushroom or toadstool in living upon the dead matter brings about its decay. The growth of the one means the breaking up or dissolution of the other.

The carbon of the dead plant is built up into the living fungus.

Experiment.—You might perform the following simple experiment:—Gather some toadstools, cut them up, and, placing them in a clean porcelain vessel, char over a spirit-lamp flame or Bunsen burner. When all moisture has evaporated, cool and note the black residue. This is carbon. We know it has not been obtained from the atmosphere, for without chlorophyll these plants cannot obtain it from that source. It is got from the dead vegetation in the soil. When the toadstool dies it is acted on by **bacteria in the soil** and reduced to carbon dioxide, water, ammonia, etc., and thus the **organic returns again to the inorganic.** This is an illustration of the **circulation of matter** which is continually going on in nature. You must think of it and try to realise it. Besides mushrooms and toadstools, other plants engaged in the same decomposing work are moulds of all kinds and bacteria.

Fairy Rings.—Have you ever noticed dark green rings of grass upon poor pastures? These are commonly known as "fairy rings." They have nothing to do with fairies, but are caused by the growth of fungi at the expense of the vegetable matter in the soil.

As they feed upon it they spread outward evenly, occupying a circular patch at first, but as they tend to exhaust the soil of certain substances supplied by the organic matter, the soil is made poorer. Thus a gradually increasing lighter patch follows the fungus growth, which thus is resolved into a ring. As the fungus itself decays certain substances (nitrogenous matter) yield materials of manurial value (nitrates) which temporarily stimulate the growth of the grass—hence the green ring.

What is meant by the circulation of matter? Write out an answer to this question.

Practical Exercises.—As an extension of the foregoing study pupils might be asked to set aside in suitable places samples of damp bread (under an inverted tumbler), jam, or fruit juice, broth, etc., for the cultivation of moulds. These should be kept in a damp and moderately warm atmosphere. The progress of growth of moulds may be watched, and the commoner ones recognised. Three familiar kinds are likely to be observed. A white one—**Mucor,** a blue one—**Penicillium,** familiar in various cheeses, and a bluish-green one which is white in the younger stages—**Eurotium** (Fig. 152).

If conditions admit of it, the teacher might boil in suitable flasks samples of the foregoing cultures in water. Whilst the contents are boiling and the steam is issuing from the flask it must be stoppered with a tight-fitting plug of clean cotton-wool A label should be attached giving the date of the experiment. If it is properly performed the contents of the flask will remain fresh and free from growth of moulds for an indefinite period. The two sets of experiments are an effective demonstration of the presence of mould germs and bacteria in the air, etc., of their destruction by heat, and of their effective exclusion from the flasks by the plug of cotton-wool. See *Aims and Methods of Nature Study*, Chapter XXIII., Processes of Decay.

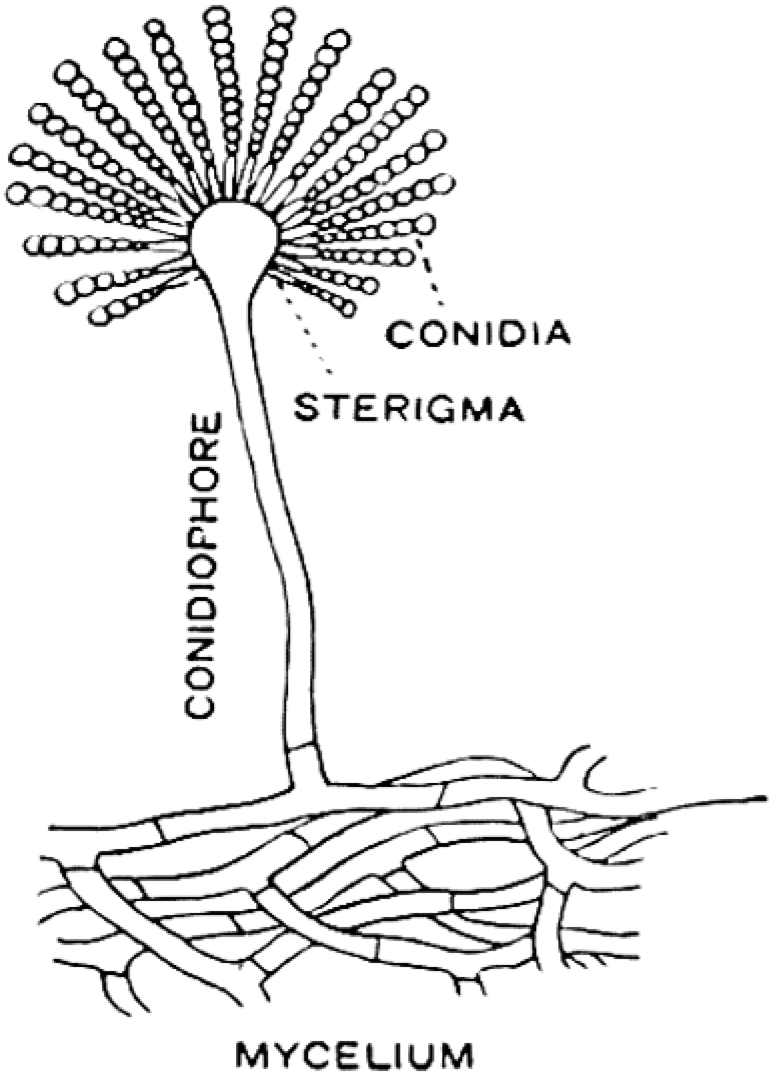

Fig. 152.—Mycelium and spore producing branch of a common mould (*Eurotium*).

LESSON LXII.

WINTER LIFE OF PLANTS.

A. BELOW THE GROUND.

[The teacher should have, for the purposes of the following, specimens of suitable seeds, rhizomes, crocus corms, various bulbs, tubers, etc. It will be necessary to deal with the subject-matter treated below in a series of separate lessons.]

General Conditions.—There are three important necessaries for the life of plants which are reduced in amount or not readily available in winter; can you name them? These are heat, light, and moisture. You readily think of the first two; in winter the sun's rays are more slanting and thus are not so warm, the days are shorter, and there is thus a further loss of heat as well as of light. But you are no doubt ready to point out that there is more moisture in winter. This is quite true; but in the cold the roots of plants cannot absorb moisture to the same extent. Thus in winter not only does less moisture enter plants, but at the same time cold winds tend to cause a loss of it through the leaves. Plants therefore require to control carefully the moisture supplies at this season of the year.

The winter is thus a time when plants require special provision for their needs. Let us try to note the chief arrangements which exist whereby plants are tided over this season of the year.

First of all there is a very general stoppage of plant activity. It is a resting time. Some plants rest entirely below the ground. No doubt in winter the underground parts are better protected than those above, and so we find that in many cases the parts which live through the winter are stored in the soil. We shall have our first set of lessons on the living parts of plants sheltered in the soil.

Seeds.—There are a great many ordinary flowering plants which complete their life within a year. These are known as **annuals.** These mostly die down in the summer or autumn after they have produced seed. The plant ceases, but the type is continued in the **seed,** which is the condition in which in their case the winter is passed. In a seed, as we have learned, there is a minute plant, provided with a food store, protected against cold and injury by a thickened covering (seed coat), and constituted to exist without moisture for a time. This is the simplest and most effective way in which plants can pass this season of the year.* Some annuals are so hardy that their stems and leaves may exist through the winter, and in mild winters they may even flower, *e.g.* shepherd's purse or chickweed. But it is upon the seed that they depend for continued existence.

Revise the parts present in a typical seed, and make a drawing to show these.

Rhizomes.—Another form in which plants exist in winter underground is that of the **rhizome.** The parts above ground, shoots, leaves, and flowers, mostly die off, but below ground the rhizome lives. The rhizome is an underground stem. It bears buds, usually scale-like leaves, and roots. It contains food material stored within its tissues. Can you name any plants with rhizomes? Some which we are familiar with are wood anemone, primrose, lily of the valley. From the buds shoots grow up into the air.

You should dig up a rhizome and examine it. Some grow horizontally, *e.g.* wood anemone, or lily of the valley. In these cases they are long and branching. Sometimes they are short and almost vertical, as in the primrose. Having washed the rhizome free from earth, draw it and name the following parts. **Buds, scale leaves, leaf scars, roots** (Fig. 153).

Be sure you understand the importance of the rhizome in relation to winter. It lives with its buds protected from the cold in the soil, and stored with food which enables the buds to develop quickly when the milder weather of spring appears.

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* Seeds of course may retain their vitality for many years.

Corms.—Another form in which some plants rest sheltered in the ground is this condition we see in the crocus What is this part termed? This is known as a **corm.** A corm is not really different from a rhizome when we consider its parts and their uses, although in appearance they are not at all alike. In the crocus the parts above ground disappear, although the leaves persist and increase for a long time after the flowers have passed away. They are at this time making food materials which are stored underground in the corm. The corm is really the lower part of the stem which is below the ground. It is swollen with its store of food, and bears buds, scale leaves, and roots.

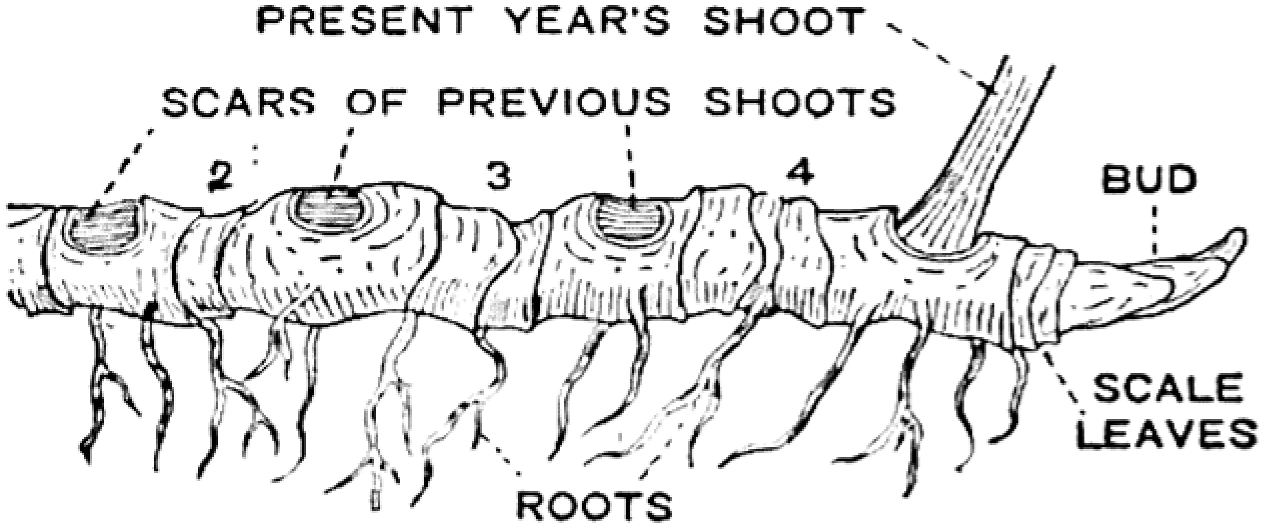

Fig. 153.—Rhizome of Solomon's Seal.
The numbers represent the growth of successive years.

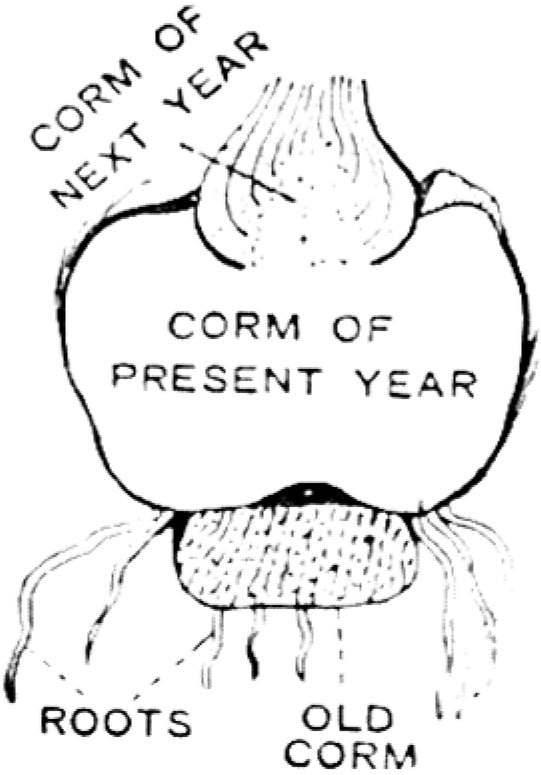

Fig. 154.—Corm of Crocus.
Longitudinal Section.

Crocus Corm.—Let us examine a crocus corm. What do we see externally? A globular body, somewhat flattened, very firm in texture, covered with brownish scales. Below this globular part is a smaller, soft, decaying mass, also brownish, and having in some cases a few dead rootlets attached. Around it and growing from the larger globular mass are living rootlets. From the top there protrudes in the centre a small bud. Now let us name these parts.

The withered mass at the bottom is last year's corm. The large mass is the corm, from which a crocus plant will be nourished in the spring. This corm was filled up from the food made by the leaves early last summer. The bud at the top will unfold the flower and leaves of the coming spring, and develop a corm for the following year at its base. We shall see this more clearly presently when we cut the corm. Meantime draw this object, naming all the parts on it. **Present year's corm, scale leaves, roots, bud, and last year's corm.**

Carefully remove the scale leaves, having first detached last year's corm. How are these scale leaves arranged? In a series of rings—three or more at different levels can easily be recognised by means of the scars they leave behind. Or you may see them attached to the corm, especially near the top, after you have removed the lower ones. Take a lens and examine the corm after you have removed the scales. Do you see the small undeveloped buds, also with brown scales, just above the attachment of the large scale leaves? There are usually a few such upon the crocus corm. These may develop and detach with small corms of their own.

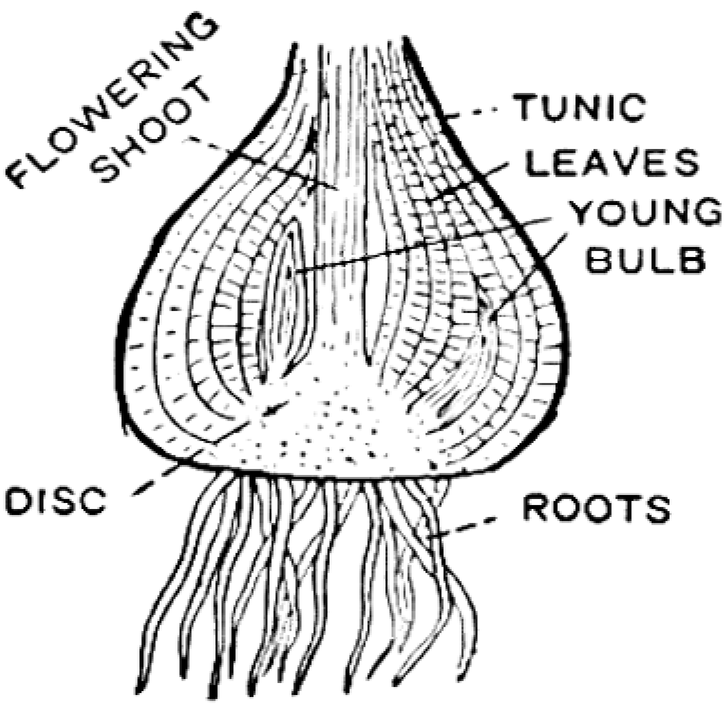

Fig. 155.—A Tunicated Bulb, cut lengthwise.

Now split the corm lengthwise and make a named drawing of what you see, viz. corm of the present year with its food store, roots, old corm, corm of next year within bud (Fig. 154).

Name some plants which form corms?

10

Bulbs.—A third form in which plants are enabled to pass the winter is that known as the **bulb.** It is commoner than the corm. What plants do you know which pass the winter in the form of bulbs? Onion, hyacinth, tulip, lily, daffodil, snowdrop are some common examples.

Now let us see wherein a bulb differs from a corm. Their uses are the same. They are a safe form in which the plant can pass the winter, and also serve as a means of propagating new plants apart from seed forming. What differences there are consist of differences in structure. We shall examine a bulb of an onion.

4×10×20×20×14

590

280

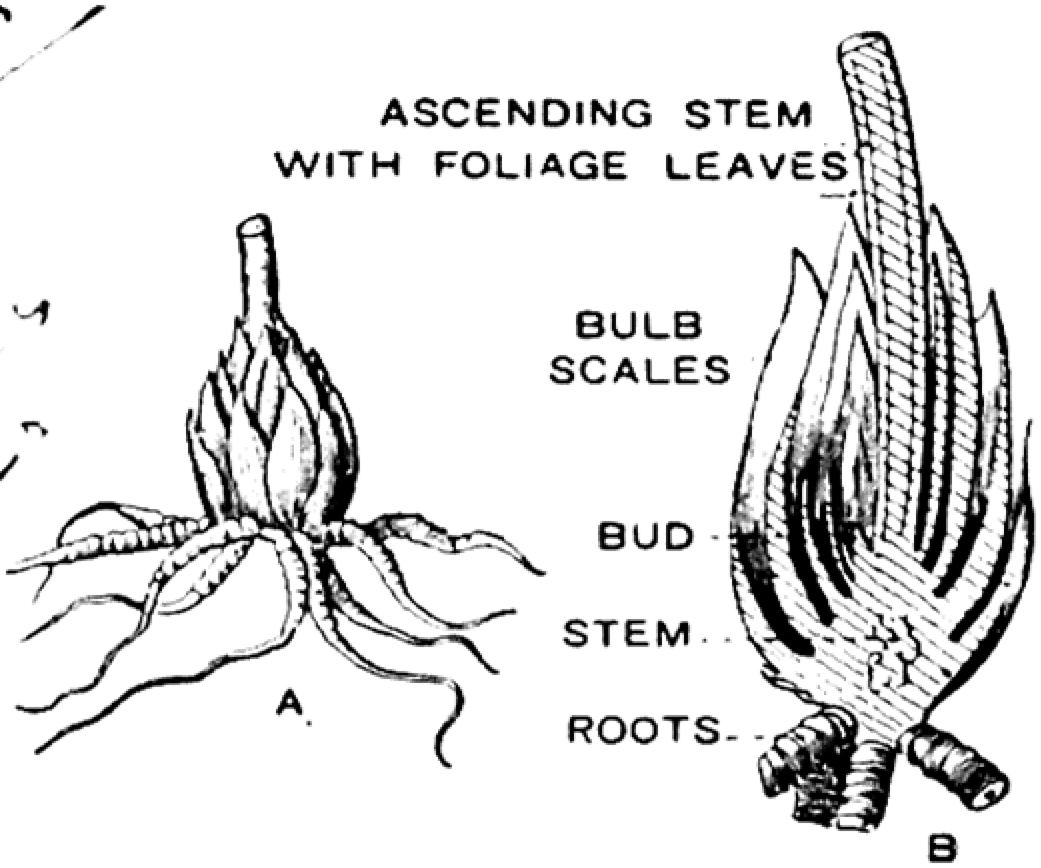

Fig. 156.—Scaly Bulb of Turk's Cap Lily (*Lilium Martagon*).
A, Entire; B, Median Longitudinal Section.

Onion Bulb.—Notice the brownish membranous scaly covering upon the outside. Trace these scales upward and note that they end in withered tips. Beneath these the bulb is made up of a number of thick fleshy layers. Trace these upward. How do they end? All the outermost ones end in withered tips also. Can you think what this means? These thick fleshy layers, as well as the outer scaly layer, are the bases or lower parts of foliage leaves. As we go on removing these we at length come upon a small bud in the middle, which is the future plant to be built up from the food stored in the thick **fleshy enclosing leaf bases.** Beneath the bud is the **short flattened stem** upon which the fleshy leaves have grown, and from the lower side of which (adventitious) **roots** are given off. Cut an onion bulb lengthwise, **draw the section exposed,** and name the parts (Fig. 155).

A bulb of this kind, in which the outer scales completely enclose the inner, is known as a **tunicated** bulb. Examine a lily bulb in which the fleshy scales simply overlap. This is known as a **scaly** bulb (Fig. 156).

Note then the difference between a bulb and a corm. In the bulb the stored food elements are to be found in leaves, in the corm they occur in the stem.

Tubers.—There is still another familiar form in which certain plants pass the winter in a resting condition. This form is known as the **tuber.** What plants do you know which form tubers? The potato is our best example of a tuber. But we have seen tubers upon the lesser celandine, and they may also be observed upon many of our native orchids.

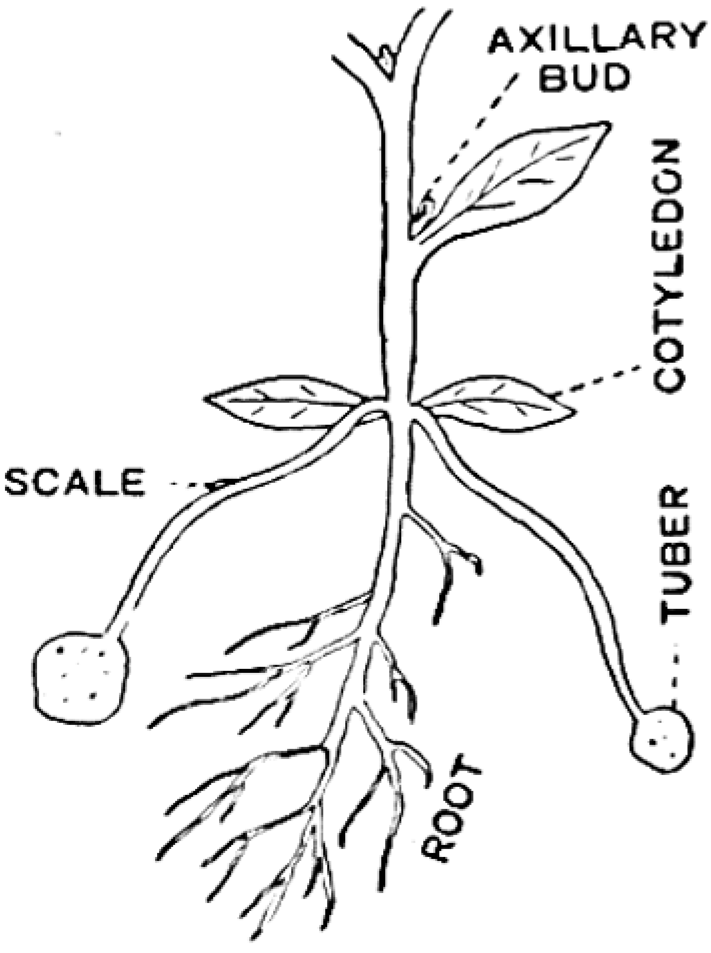

Fig. 157.—Seedling of Potato with Developing Tubers.

The uses of tubers are similar to those of rhizome, corm, or bulb. Examine an ordinary potato, a tuber of the lesser celandine, of the dahlia, and of the early purple orchis when an opportunity arises. In the case of the potato the tuber is a part of the stem. How do we know this? Because the parts upon which they grow have the structure of stems and bear scale leaves. The tubers may arise at their tips or in the axils of scale leaves (Figs. 157, 158).

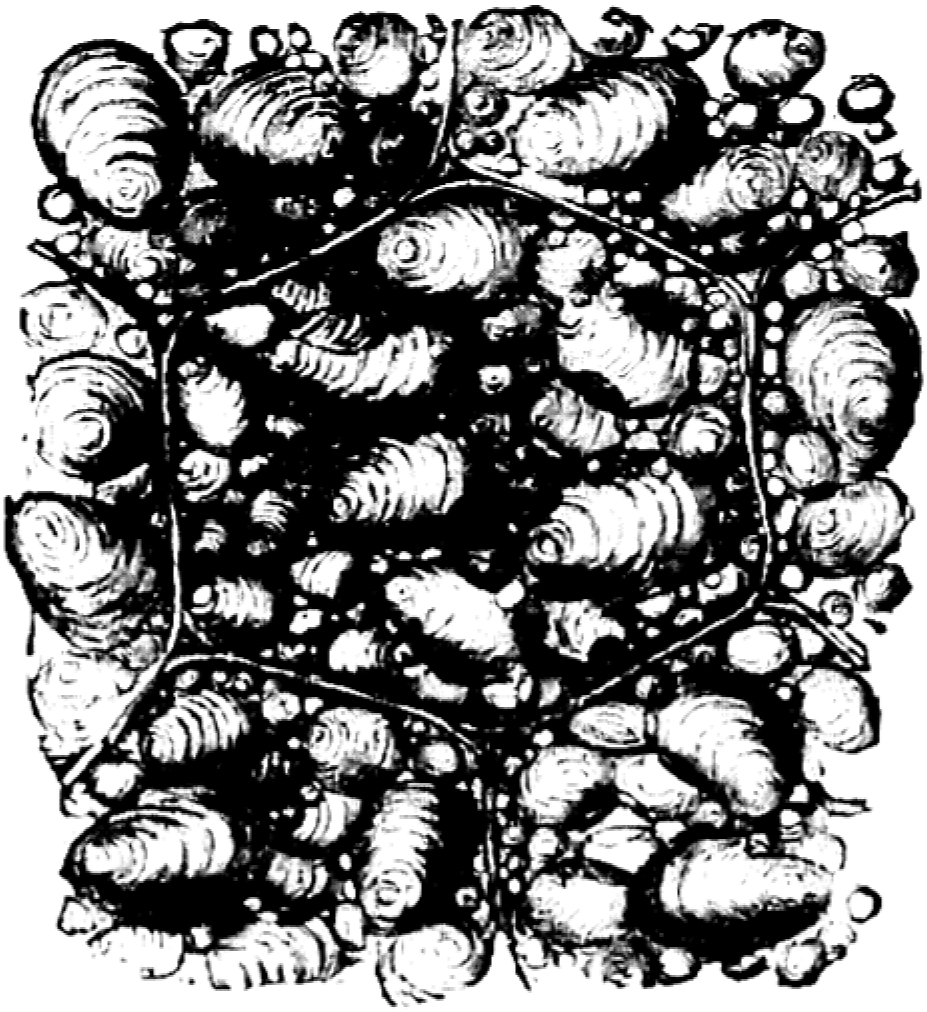

Fig. 158.—Cells of Potato Tuber showing Starch Grains, greatly magnified.

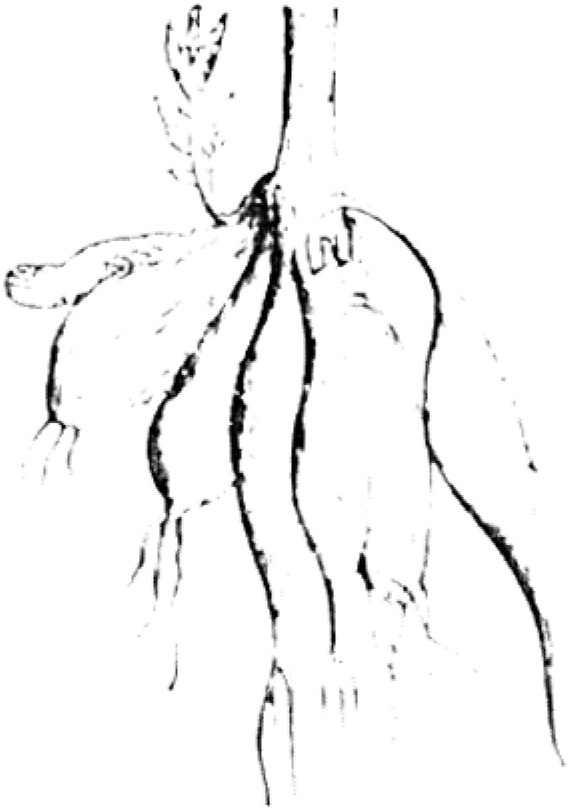

Fig. 159.—Tuberous Roots of the Dahlia.

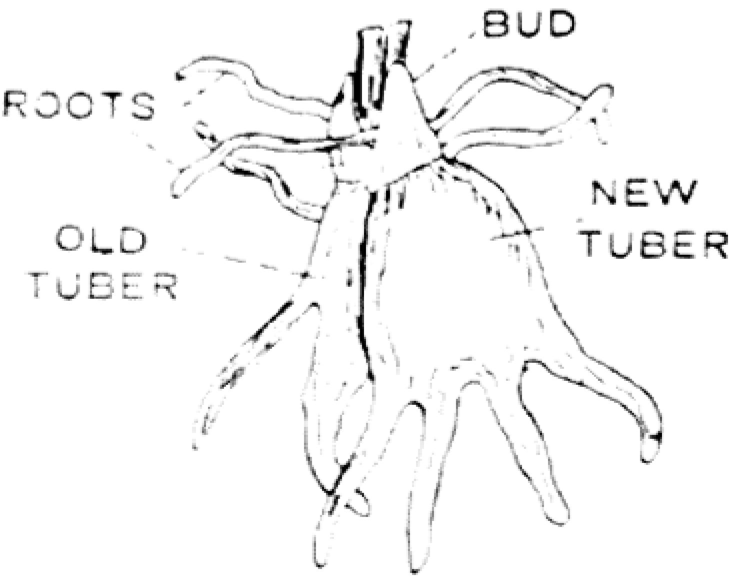

Fig. 160.—Palmate Tuber of an Orchid.

Besides these facts, the tubers of the potato show themselves to be portions of stems—not roots—in their **possessing buds,** *i.e.* the "eyes." It is a familiar fact that a portion of a tuber having an "eye" will when planted under suitable conditions develop a potato plant from the "eye" or bud, growing at the commencement at the expense of the stored up food in the tuber. In the case of the celandine, dahlia, or orchid the tubers are formed upon the roots (Figs. 159, 160).

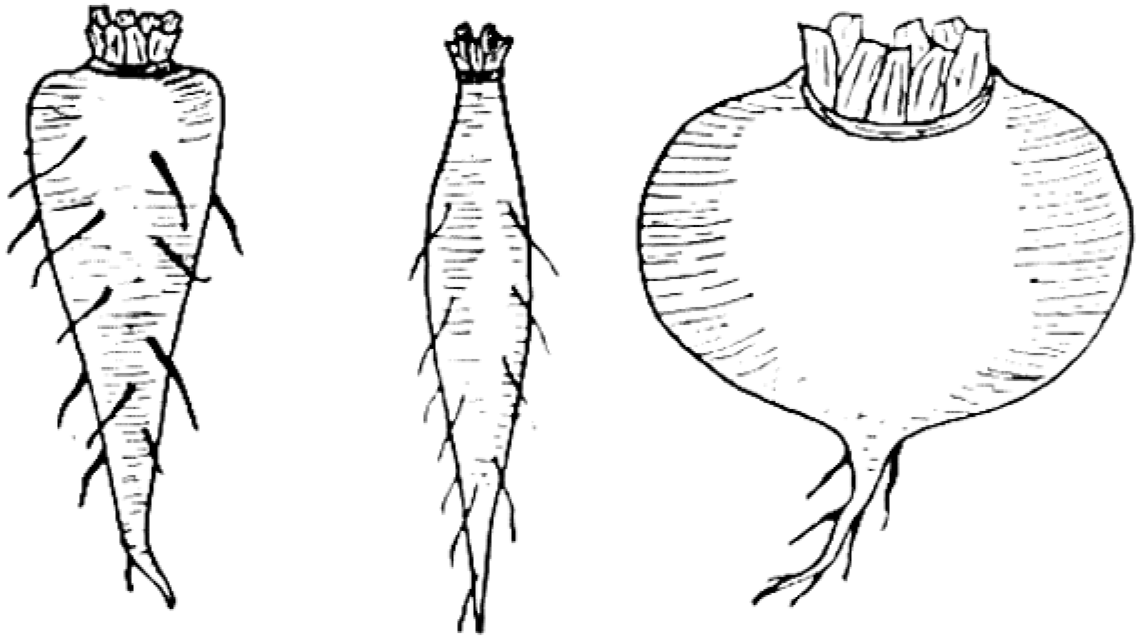

Fig. 161.—Tap-roots of Biennials.

Besides root tubers, the roots of perennial plants are to be found stored more or less with food materials against the needs of the following year. In the case of biennials too, the root may be stocked with reserve food materials which go to the second year's growth, and are greatly swollen in consequence. Can you name some common vegetables which have roots of this kind? Carrot, beet, turnip are examples (Fig. 161).

LESSON LXIII.

WINTER LIFE OF PLANTS.

B. ABOVE THE GROUND.

We noted in previous lessons that the conditions of winter in our land induce a resting-time in the plant world generally. Growth and food-making for the most part cease. Let us see how those parts which persist above ground are adapted to the severities of the season.

Trees and Shrubs.—Most trees and shrubs **shed their leaves,** but there remain above ground stem, twigs, and buds. How are these protected? In the stem and branches there is a **layer of cork** which acts in two ways in particular. It protects the plants from losing water, and it keeps in the natural heat of the living parts of the tree within.

Many people think and speak of trees in winter as being dead. Their branches may be bare, but they are not dead, for they not only contain living sap but they bear, exposed to view, **living buds.** What are these buds? The buds which we find upon the trees in winter are the undeveloped shoots of the following or later seasons. When the winter has passed they expand, unfold their leaves, and lengthen their stalks, thus clothing the tree afresh with living growing twigs and leaves.

Buds.—Buds are delicate structures, full of tender young tissue, such as might readily be destroyed by frost or by loss of moisture. Open a tree bud and note the soft tissues within. How are they enabled to withstand the rigours of winter? To answer this question you must examine a few buds of different trees. Take, for example, a sycamore twig and with a penknife carefully remove in turn the parts from the outside of a bud. The terminal bud is rather larger than the others and it should be taken. What do you find? Such a bud is enclosed by a large number of **strong overlapping scales.** The outer ones are brownish, others are green with brownish margins, the inner ones are green, downy along the margins and in the inside, and altogether you find that the tender shoot and its minute leaves are extremely well protected both against the cold and the possible loss of moisture (Fig. 162, B).

Sometimes the **scales are gummy** or resinous, as in the horse-chestnut, the black poplar, and aspen. Others are downy upon the outside, as in the sallow, osier, and white poplar. Examine the buds of some of these. What is the meaning of these features?

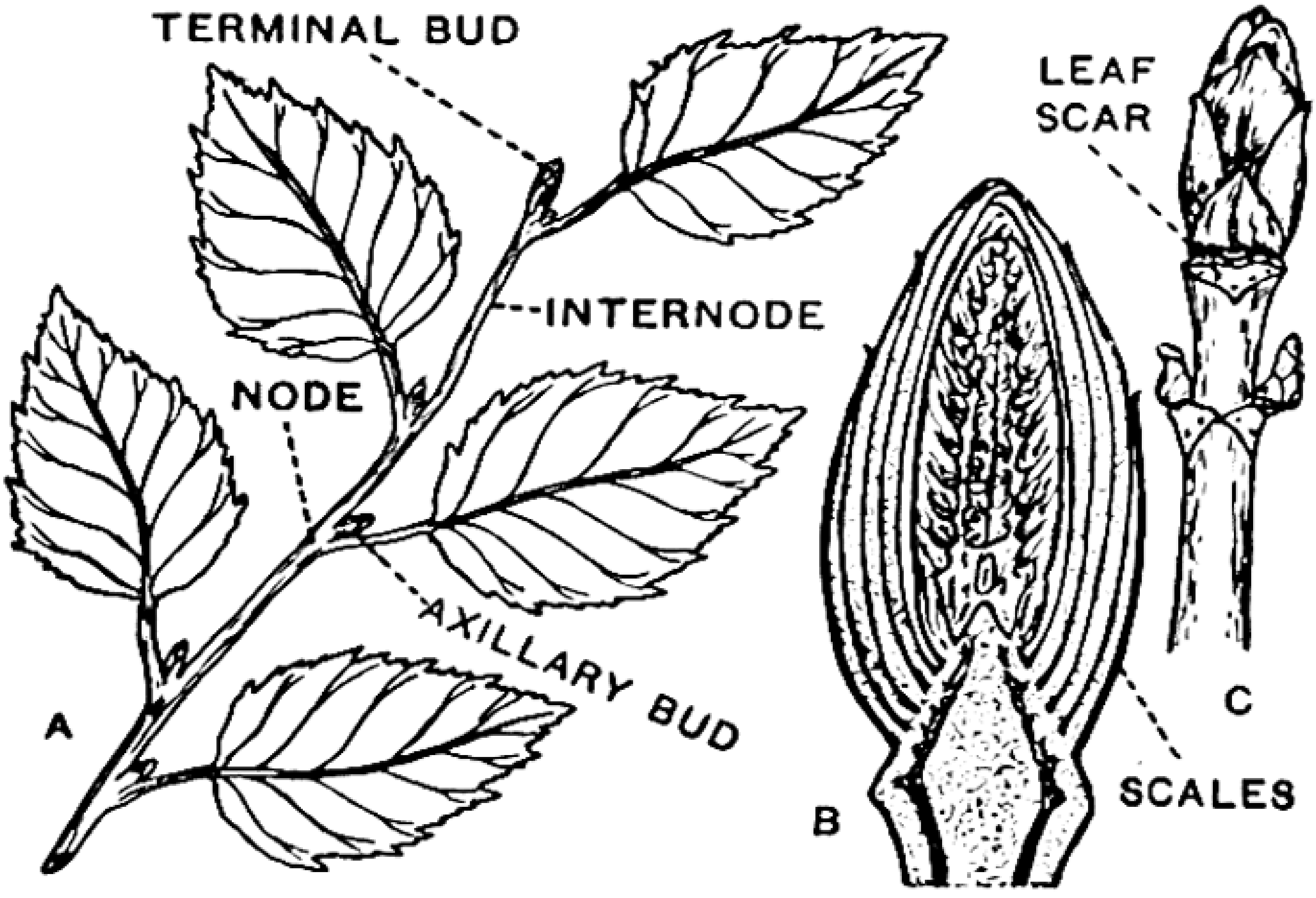

Fig. 162.—A, Summer Twig with leaves and buds; B, Bud in winter, shown in section, sheathed in protecting scales; C, Bud in spring, having shed its scales, and about to expand.

Evergreens.—In other trees the foliage persists for a number of years. These are the evergreens. As an example of these let us look at the leaves of the **Scots pine.** They resemble those of the spruce fir or of the yew in their adaptations to winter. First notice their shape, long and narrow, with little surface exposed. Secondly, the outer layers of cells composing the skin of the leaf (epidermis and hypodermis) are strong and thick-walled. Upon the epidermis there is a thick **cuticle** (p. 145). Thirdly, the stomata (air and water-vapour openings) are sunken below the surface. All these characters tend to restrict the giving-off of moisture as well as protect the food-making tissue from the cold (Fig. 163).

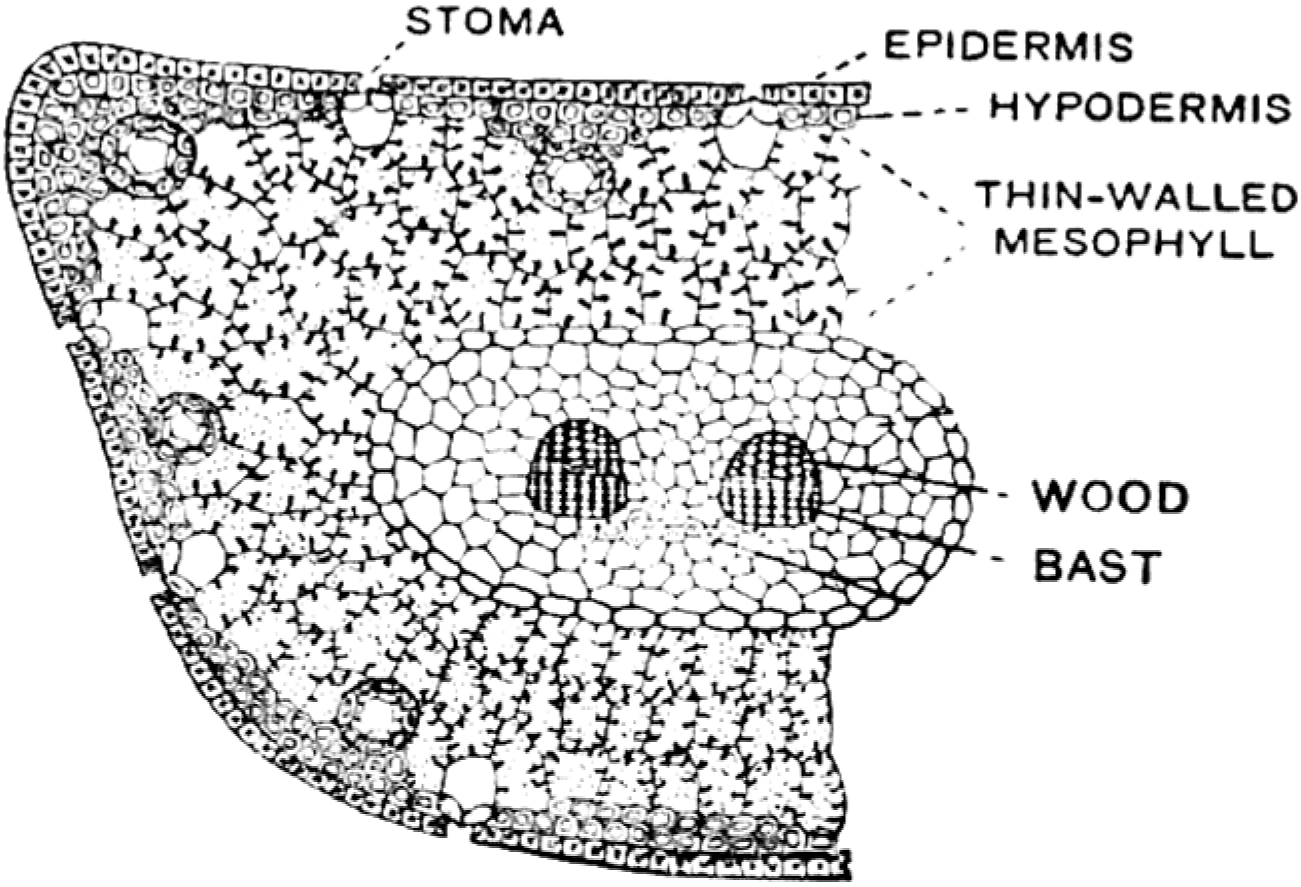

Fig. 163.—Transverse Section of Leaf of Pinus.

Examine a series of leaves of evergreens, *e.g.* laurel, rhododendron, holly. Discover features about them in which they agree, and in which they differ from the leaves of deciduous trees. Explain these in relation to winter (p. 350). Apart from the leaves, the twigs and buds of the evergreens are protected as other trees are.

Herbaceous Perennial Plants.—In many of these, we have noted, all the parts above ground die down, and the plant is renewed from below the ground. There are, however, others whose stems and foliage persist through the winter, and on these we can often see its effects. Look, for example, at the grass of the fields or the foliage of the waysides, and note how, especially if there is little snow, it gets torn, damaged, and withered. When there is much snow upon the ground you can see that such plants do not suffer nearly so much.

Have you written out a list of the chief means adopted in our plants at home to protect themselves against the dangers of winter? You must also remember to observe for yourselves as many of these things as you can.

LESSON LXIV.

CONE-BEARING TREES.

[Small branches of Scots pine, larch, and spruce fir, together with some cones of each tree, are required for this lesson. They can, without much difficulty, be obtained from nurseries; as it is suggested that the lesson be taught in winter, the aspect of the trees in this season, of course, is the chief theme.]

Identification of Common Forms.—We have here some branches of three well-known trees, and upon these you see certain parts called **cones.** Such trees are known as cone-bearers (Coniferae). Let us first learn their names. Pick out the one which is most familiar to you. No doubt you know it as a Christmas tree. It is also known as the **spruce fir.** Then we have the **Scots pine.** You will know it by its long, needle-like leaves grouped in pairs. Our third example, which you notice has no leaves upon it at this season, is the **larch.** Have you written down these three names? (Figs. 164, 165, 166.)

What name do we give to those trees which bear green leaves in winter? They are known as **evergreens.** Two of our examples, you notice, are evergreens, but you must know many others of this habit; try to think of some. How many of the following do you know?—Yew, juniper, cypress, holly, laurel, rhododendron.

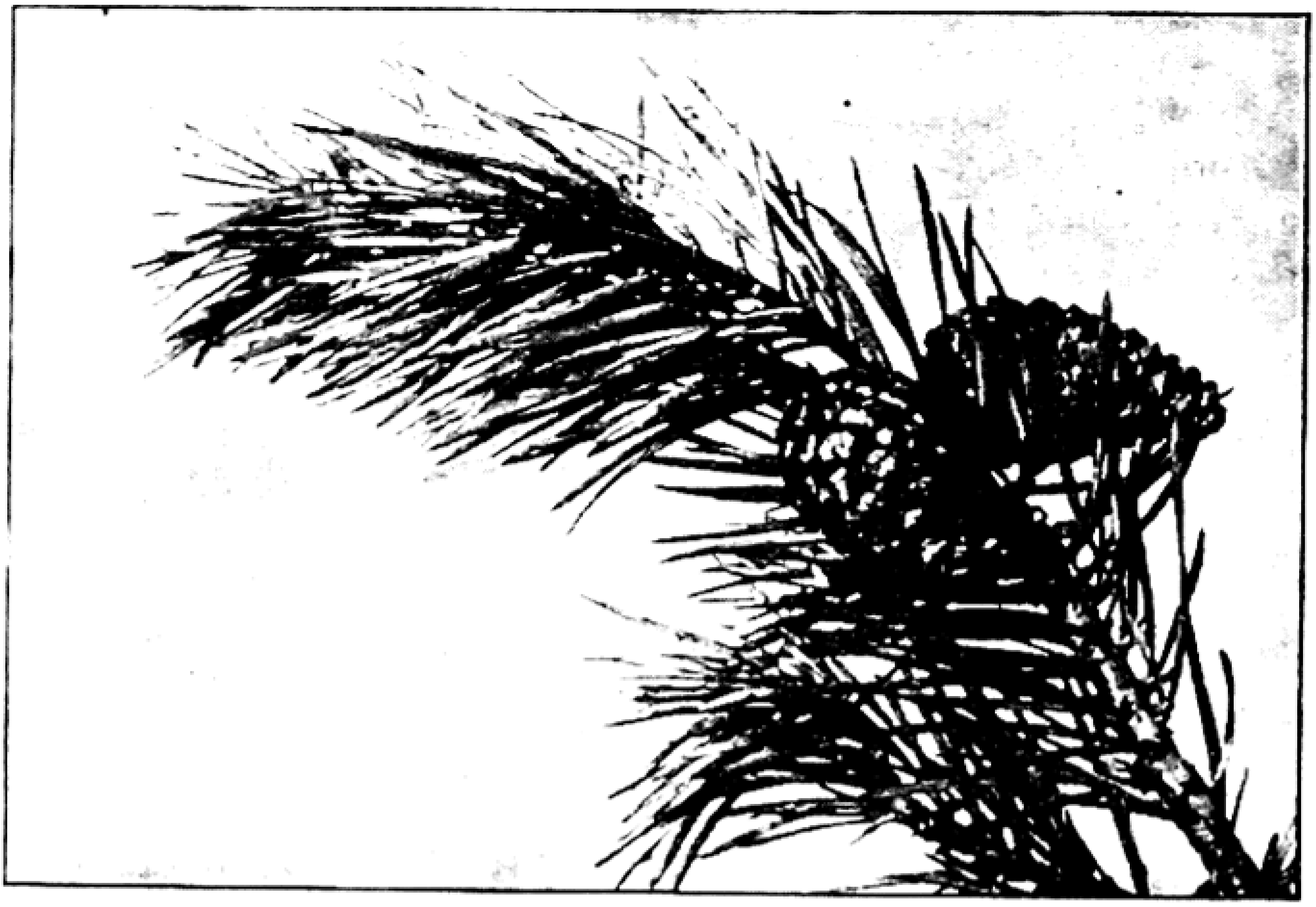

Fig. 164.—Branch of Scots Pine with cones.

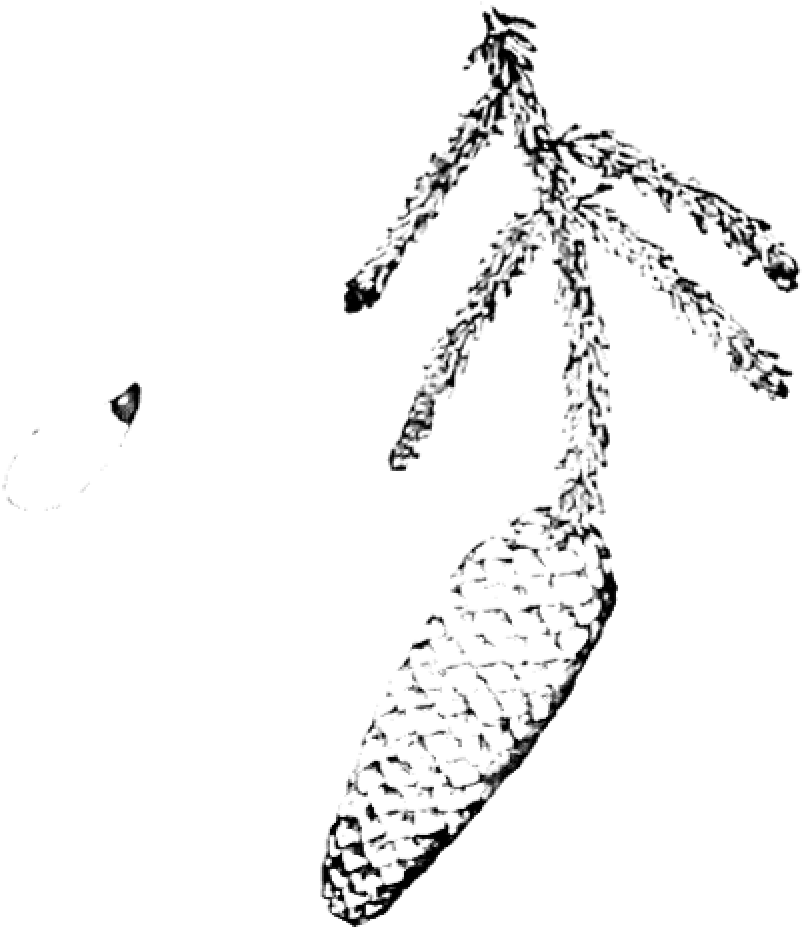

Fig. 165.—Twig of Spruce Fir with cone attached. Alongside a winged seed is shown upon a large scale.

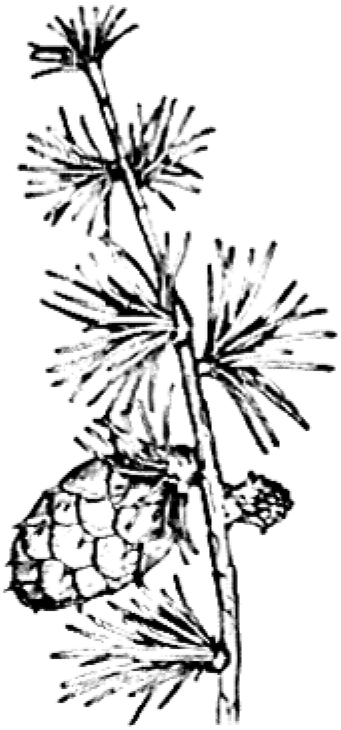

Fig. 166.—Twig of Larch in Spring.

The Leaves of Evergreens.—Do evergreens shed any leaves? This question is not difficult to answer. Of course they do. If you have ever walked through a piny wood, you will be familiar with the carpet of "pine-needles" (fallen leaves) beneath the trees. Beneath the holly or rhododendron you will also find fallen leaves. Also when we look at the inner parts of the branches of the spruce fir, for example, we see the scars or marks at the places where leaves once grew, but which have since fallen off. The secret of the evergreen is just that, although it sheds its leaves, it does not shed them all at once, and, further, the leaves last longer than those of other trees.

Leaves which remain upon the trees or shrubs in winter require to be stronger than others. They need to be able to resist the wind, the frost, and the weight of the snow. Do you notice how these **narrow leaves are suited** to withstanding wind. Their shape does not admit of their being torn, and yet there are so many of them that they display as much green as other trees with larger leaves do in summer. Then their glossiness is useful in causing the **snow to slip off,** which might otherwise lie so heavily upon the trees as to break the branches. Indeed, in spite of this the branches are sometimes broken by the weight of the snow. And the glossiness is due to the outermost layer of the leaf being specially thick, an arrangement which protects the leaf against frost besides helping it in other ways (cf. p. 360). It is noticeable, too, that the leaves of the larch, which are softer and more tender, do not remain upon the tree through the winter as is the case with most cone-bearing trees.

Make Drawings.—Make a drawing, larger than natural size, of a pair of pine needles, of a leaf of the spruce, and of a little bit of the larch. Show in this last case the absence of leaves, and the place where the leaves ordinarily arise.

If you make next a drawing of a small portion of a twig of each of these, you will discover several interesting things, to which the differences in their general appearance are due.

Leaf Arrangements.—In the spruce fir notice the following. The leaves are arranged upon the various twigs in a spiral manner; they are of medium length and have four edges (quadrangular in section), and are fairly stiff and sharp. In the Scots pine the leaves are longer; they are grouped in pairs. Each pair of leaves arises upon a very short shoot, which has small scale leaves at the base. These short shoots are not present upon the spruce fir tree. The pairs of leaves are grouped in a spiral manner around the longer shoots. In the larch the short shoots are thick and stumpy, and bear their soft green needle-like leaves in tufts.

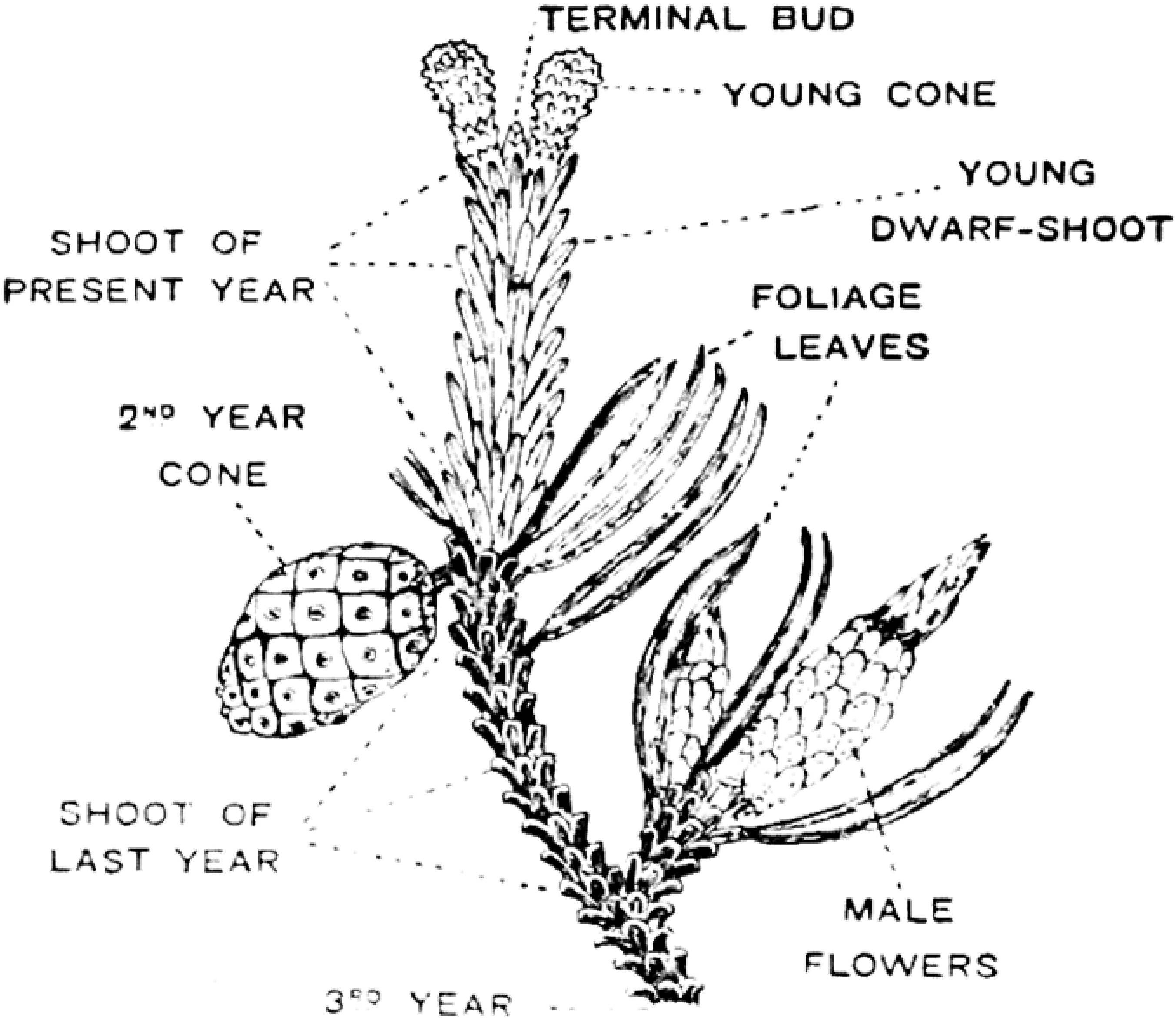

Fig. 167.—Branch of Scots Pine, cut in May, most of the older dwarf shoots and foliage leaves removed.

Cones.—You must now examine the cones of each tree. Compare these. There are differences to be noted in size

—which is largest and which smallest? How do they differ in the texture of their scales? The scales of the Scots pine are thicker and more "corky"—those of spruce fir and larch more fibrous or scaly.

Notice which of the three falls most readily to pieces, viz. the spruce cone. The Scots pine cone falls most readily to the ground. Which persists longest upon the tree? The larch cone. You should try to see the cones in both early and later stages; in summer remember especially to look for the pollen-bearing cones of the Scots pine (Fig. 167).

Make a drawing of each kind of cone. What do we find within them? If the scales of an opening cone are separated, above each will be found a pair of seeds, each with a thin, wing-like membrane attached. Carefully break a cone to pieces so as to obtain some seeds, examine and draw them. Write down below your drawing the use of the membrane to the seed (Fig. 168).

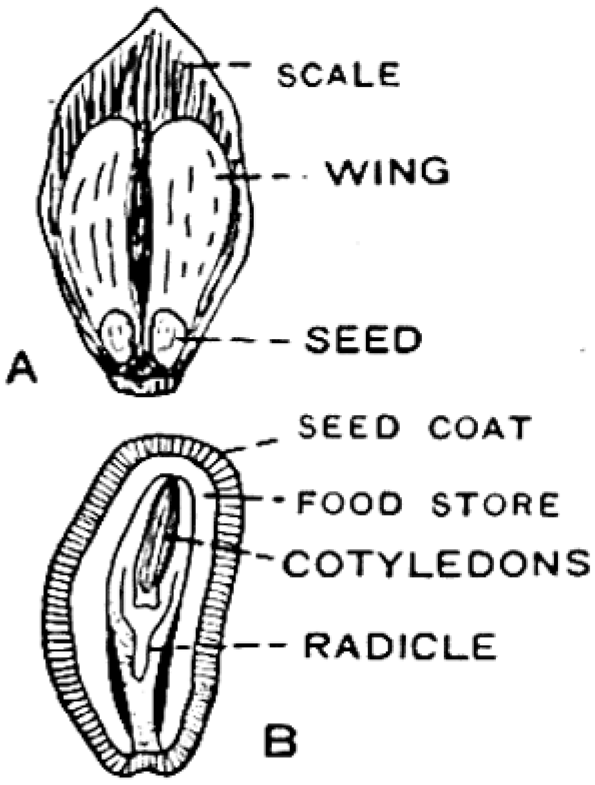

Fig. 168.—A, Scale of Pine Cone showing seeds; B, Longitudinal section of seed.

Note that the seeds are exposed upon the surface of the scale and are not enclosed by the carpel (**Gymnosperm**). The real carpel is a small scale concealed beneath the larger one to which the ovules are attached (Fig. 169). This may be seen on a young cone in early summer.

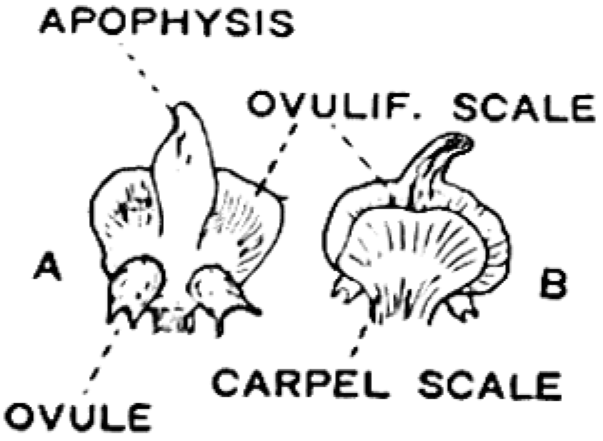

Fig. 169.—Scale of Pine Cone, before seed is formed. A, upper view; B, lower, showing the carpel scale.

The foregoing may be taken as a series of lessons in which the three trees are dealt with separately. Subsequently comparisons may be noted and tabulated as indicated in the study here outlined.

LESSON LXV.

A PIECE OF COAL.

[In winter, when the warmth and glow of a coal fire are appreciated, a study upon coal is not inappropriate.]

Appearance.—Here is a piece of ordinary coal. Let us commence our study by examining it closely and describing it. It is a black, stony-like substance, with glistening surface. It is brittle, and when broken frequently fractures along even surfaces—planes of cleavage. We can see the parallel lines upon the surface along which it tends to split. This is the appearance of an ordinary bit of coal, but there are different kinds; all have not the same appearance exactly. Nor are all kinds of coal made up of the same substances in the same proportions. Although we cannot prove this at present it is an important fact to remember because it distinguishes coal from a true mineral substance.

Sources of Coal.—Do we all know where coal is obtained? In a general way I suppose we know that it is obtained from below the ground. It is one of the substances of which the crust of the earth is composed, and is found in various parts of the world. Do you know whereabout in our own country there are coalfields? Yorkshire, South Lancashire, South Wales, and in the east and centre of Scotland are some of the chief places.

Coal not a Mineral in Origin.—Now there is one thing we have already mentioned about coal, viz. that it is to be distinguished from a true mineral substance, *i.e.* from substances of a stony nature such as are ordinarily quarried from the earth. What reason can you give for not regarding coal as a mineral? What do we use it for mostly? For burning. Coal burns. To what is the blackness of coal due, and to what is its property of burning due? The answer in both cases is the same, viz. to the presence of **carbon.** Do you know another common substance containing carbon in a condition for burning? Wood. Have you learnt anything which might suggest to you where the carbon in the wood came from? It was built up into the trees in the ordinary process of natural growth.

What organs in the tree are the chief means by which carbon finds its way into plants? The leaves. From what source do the leaves get the carbon? They obtain it from the air, from a gas containing carbon and oxygen, known as carbon dioxide. What power (energy) does the leaf need in order to be able to split the carbon away from the oxygen? The energy of the light of the sun. When we burn a piece of wood we get both light and heat from it, this is the **light and heat which went to the making of the tree** when the leaves took the carbon from the air. It is the sun's heat and light, once imprisoned, perhaps hundreds of years ago, and again set free. Think over this carefully and store the thought in your mind.

Now let us return to our piece of coal. If it is not stony in its nature, what is it? The answer is: it is the remains of plant life upon the earth many, many ages ago, far, far back in time as compared with the trees which grew hundreds of years ago. Of course you wish to ask the question: how do we know this? Now it will not be possible for you to get a complete answer, but here are some things to think about which will help you to grasp the truth of what you have been here told.

1. Coal is unlike the minerals which make up the earth's crust in containing a very large percentage of carbon, but not always the same percentage. That is, it is a variable thing not constant in its constituents.

2. It frequently is found to contain plant remains in a fossil state, and when carefully prepared and examined microscopically it generally shows the **same structure as plants do.** We can tell, for example, that some of the coal from the Yorkshire coal beds is made from the wood of cone-bearing trees. Other coals show that they have been formed from ancient ferns and club-mosses.

3. Coal beds in Britain occur above beds of fireclay or shale into which roots sometimes penetrate from the coal above. These beds were thus the soil in which the plants grew.

4. Existing substances are known which may be looked upon as representing different stages in the changing of plant substance into coal, although we need not suppose that all coal has passed through each of these stages. These substances are:—

(*a*) **Peat.**—It is mostly formed from marsh plants, such as bog-mosses.

(*b*) **Lignite or Brown Coal.**—This is much more compressed than peat, and has evidently undergone more chemical change. It is very light. It is found under similar conditions to that of coal.

(*c*) **Coal** comes next. There are various kinds, differing in appearance and composition. It contains besides large quantities of carbon, oxygen, hydrogen, and small quantities of sulphur and iron. Have you not noticed yellowish streaks in coal, brassy looking? These marks are traces of a compound of sulphur and iron, known as **iron pyrites.**

(*d*) **Anthracite** comes after ordinary coal. This consists mostly of carbon. It burns with little smoke, a small flame, and very great heat. Unlike ordinary coal it does not show any trace of plant structure. It is more stony-looking than ordinary coal.

The Making of Coal.—How have plants of far off times become transformed into coal? Probably in most cases in the following way. The land upon which the vegetation grew slowly sank and became covered with water. There was deposited from the water materials carried by it, such as sand and mud. This went on for a very long time, and probably the land rose and fell many times. The buried plants did not decay in the ordinary way, but seem to have undergone a kind of **slow burning.** Compare what goes on inside a manure heap. This is another kind of slow burning. The carbon in the coal did not escape as carbon dioxide. Then as the layers upon the top increased through time very great pressure came to be exerted, so that the plant substance was compacted into the dense form of coal.

How long ago is it since these things took place? We cannot answer such a question in years. But we know from a study of geology that the plants from which coal was made grew upon the earth long ages before mankind appeared. We know, too, from a knowledge of the plant remains they contain, that some coals are much older than others.

Coalfields.—Here are two things for you to find out. One is, where in Britain are our principal coalfields; the other, how is coal brought to the surface of the ground?

Uses of Coal.—What are we doing with coal at the present time? We are not only using it for fires in our houses or for making gas and obtaining aniline dyes, but using it to drive railway trains and speed great liners across the oceans, to drive battleships and propel machinery of all kinds. Is it not interesting to think that mankind is able in all these ways to use the energy of the sunlight which fell upon the earth very many ages before he himself came into being?

LESSON LXVI.

TREES IN WINTER.

THE BARE TWIGS.

[**General Revision of Past Studies of Trees.**—In our various studies of trees throughout the year we have noted the dominant aspect in each season. Thus in spring we were able in particular to deal with the opening of the buds, and the flowers of trees; in summer the wealth of foliage illustrating well the struggle for light in the food-making work of plants. In autumn the formation and dispersal of fruits, the colouration and fall of the leaves, marking the waning activities of the year, occupied our attention. And now in winter the appropriate theme is the resting tree.

This is a fascinating study on the larger scale, but it will be best with our pupils—to begin with at all events—to direct our attention to a particular case. Any common tree will do. We take as our example a twig of the sycamore. It is desirable that twigs should be supplied to the scholars. If they are scarce, the same twigs might be used in different classes in the same school.]

Aspect of Trees in Winter.—You hold in your hand a twig cut from a sycamore tree. Before we begin to look at its various parts, let us think of the tree from which it was taken. Like most of our trees it stands bare of leaves in winter. Some people think a bare tree cold and uninteresting. They would not do so if they looked at the tree in the right way, or if they knew as much about it as you do.

I think the best way in which to look at a tree in winter is to stand fairly near and look up at the tips of the branches with the sky behind. Do this with a few trees, and you will agree with me that the bare trees have each a beauty of their own and that all are attractive. You will notice, too, that each differs from its neighbour in appearance when so viewed, so that we can tell the tree by looking at it in this way. This will be quite easy if you study the twigs closely in your hand as we are now going to do. One of the reasons why we are studying the twigs closely is that we may be able the better to admire the whole tree and to understand it.

Description of a Twig.—Now let us look at the twig. I think it will be best for you to spend a little time at first drawing it, shaping the buds as well as you can, putting in the various kinds of markings, and counting nothing unimportant.

Having done this, we will next try to describe it in words. What is the general appearance of the twig? It is rather stout and strong-looking, firm, not bending easily, nearly straight or very slightly curved, not bent where the buds arise, as many twigs are. Then it is cylindrical. We mean that when it is cut straight across, the cut surface has a circular border. What is the colour of the twig? If your twig is quite short, it will probably be brownish with a hint of green below. Peel off carefully a little of the outer skin. What do you find? The skin is rather thin, lightish brown, and beneath it the substance of the twig is green. But if you examine a longer twig at the end furthest away from the tip you will find the outer skin thicker and darker in colour.

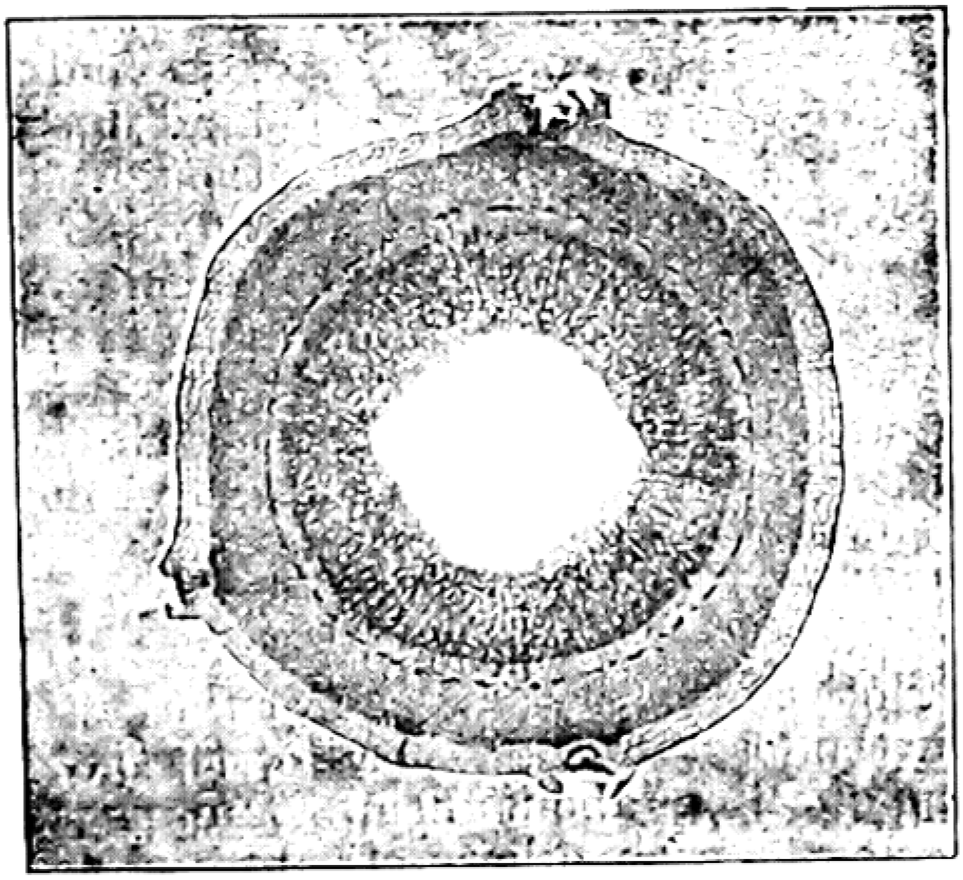

Fig. 170.—Transverse Section of Stem of Elder, showing three Lenticels.

Look closely at the surface of the twig. You see that it is glossy and that the surface is marked all over with lightish spots. These spots are slightly raised, they are longer than broad, they are soft in the centre and have a firm edge. If you have made a careful drawing these will be seen in it. These marks look like broken places in the firm polished "skin" of the twig, do they not? Do you think these are simply chance cracks in the bark? Why do you not think so? Because they are all of the same shape and size, and seem to have something to do with the inside of the twig rather than to be marks made upon it from the outside.

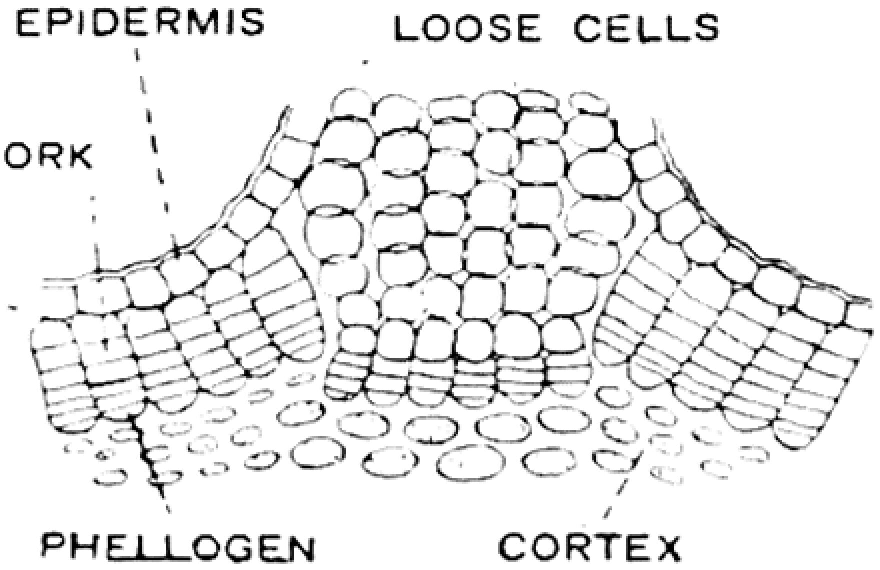

Fig. 171.—Section through a lenticel, magnified.

These are really the breathing openings (**lenticels**) of the twig. We do not find the same kind upon leaves, although these have very many small openings for the passage of air also. The openings in the twig are closed in winter when the tree is resting, but at other times, when it is active, they are open and through them there goes on an interchange of gases and passage of water-vapour between the soft parts within and the air (Figs. 170, 171).

Buds.—Notice next the buds. For the present we will look only at the part near the end of the twig. Answer the following questions about them. How are they placed? In pairs, **opposite** each other. Each pair stands at right angles to the next above or below. There is at the tip a single bud, or it may be two. Are they all of the same size? The end bud is slightly larger than the others. How are the buds covered? By a number of reddish green scales with brown edges.

Leaf Scars.—What do you see just below the paired buds? A pale crescentic scar. On it you can also see a row of dots. What are these scars? I am sure you can answer this. Are they not the marks left upon the place from which the leaves fell in the autumn, and the dots represent the now closed channels along which the fluids passed to and from the leaf. Be sure that all these things appear in your drawing. Note particularly the relation between bud and leaf.

Examine the twig once more, passing your eye along it from the end bud backward. Having passed down a little way, do you discover that the twig consists of successive sections marked off by a series of closely crowded **ring-like scars?** Yes. Can you think what these ring-like scars are? Look at the tip of the twig once more. Next year, when the buds in this position upon the trees swell up and open, the twigs will lengthen out and the scales will fall away. What trace of the bud will be left at this place? Just the scars left by the scales around the bud. Looking back again at the close ring of scars further down the twig, you see that these are just the marks left by the scales around the end bud of the previous year. This section of the twig then, you see, is last year's growth, and from its ring scars back to its next set of ring scars is the growth of the year before, and so on.

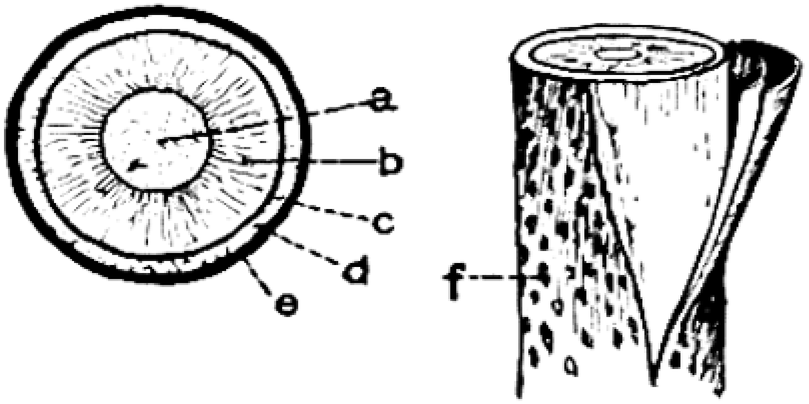

Fig. 172.—Portion of Sycamore twig: a, pith; b, wood; c, region of growth (cambium); d, cortex; e, epidermis; f, lenticel.

If you look back upon some of the older parts of the twig you will find buds which have not developed. You can see, do you not, that whilst some buds of a year develop into branches some do not. Are these latter ones dead? No, these are not dead but **dormant** buds. Should the tree require them, *e.g.* in the case of the terminal portion of a branch being destroyed, some of these dormant buds commence to grow and form new shoots (deferred shoots). See Fig. 28.

Section of Twig.—Look now at the cut end of the twig. In a section of a twig of the present year's growth, you will be able, with the help of a lens, to distinguish the following:—

The outer skin (**epidermis**), which is also seen upon the surface of the twig (Fig. 172, *e*).

A greenish layer, soft, and easily penetrated by a pin point (*d*)—**cortex.**

A harder layer, which offers more resistance to the entrance of the pin (*b*). It is pale green in colour —**wood.** Its outer border (*c*) is darker—**bast.**

A central soft layer, spongy in texture (*a*)—**pith.**

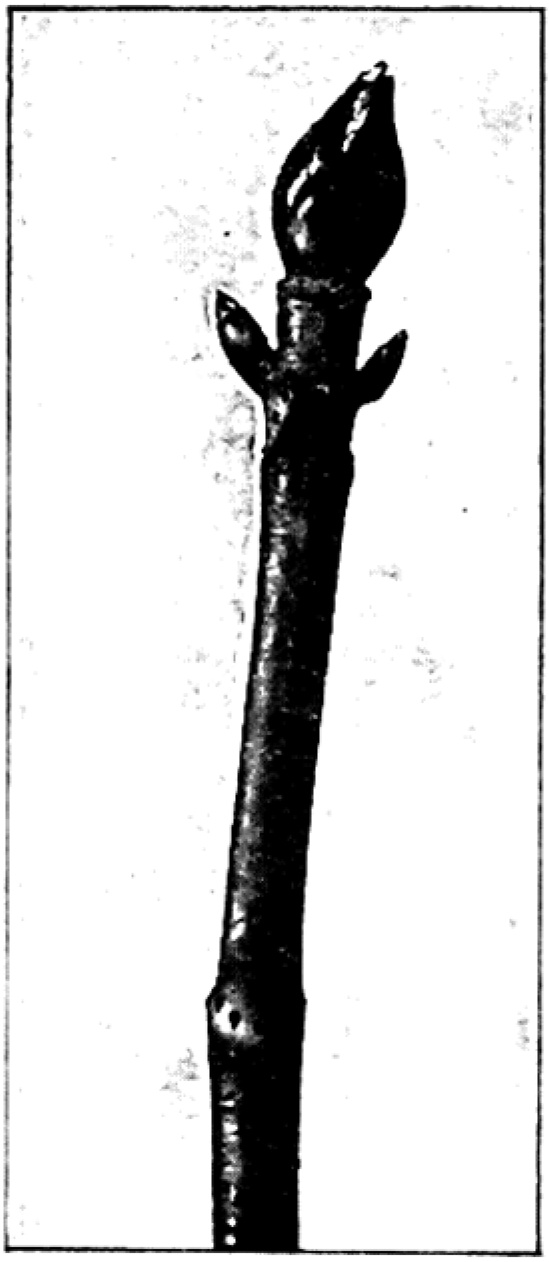

Fig. 173.—Twig of Horse Chestnut in winter. Note straight or slightly bent form, horseshoe-shaped leaf scars, opposite buds, which are sticky, and clear ring scars, in this type of twig. Ring scars are not present in the figure.

The layers are really more complex than this method of examination shows.

Let us now peel off the outer layer at the place where it yields easiest. Where is this? Do you not find that the twig peels most readily in the region of the outer border (*c*) of the pale green layer (*b*)? What do you think is the composition of this layer (*b*)? This is wood. You can see it forms a ring around the spongy layer in the middle. This spongy layer is known as the pith. Cut the twig farther back, say through the section of the previous year. Does the pith occupy as much space here? No. And the older a twig we take there is less of it, until we find there is none at all in the sections a few years old. It gets crushed out by the growth of the wood.

You should compare sections through different parts of the twig, when you will find you can recognise two **rings of wood,** or three rings, according as the twig is two or three years old, and so on. A ring of wood is added every year.

We need not here follow the section further in detail. If a similar twig is peeled in the spring in the way we have done, it will be found to be somewhat wet and sticky just against the wood. There is much sap here at this time, because this is the region (**cambium layer**) where growth in thickness is going on. Just next to it, on the outer side, is a region termed the **bast**, down which the food made in the leaves is passed and distributed throughout the tree. The water and mineral salts in solution from the soil passes up the later-made wood. The pith serves as support of the very young twig until the wood is formed, after which it is gradually replaced.

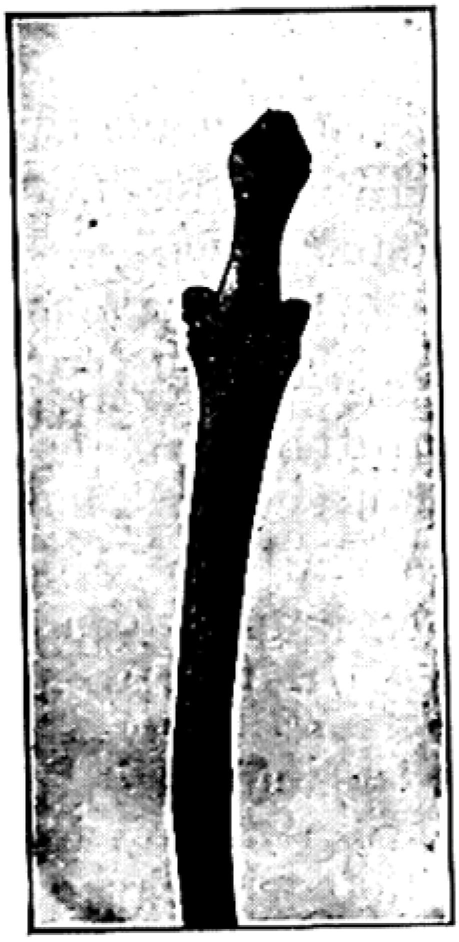

Fig. 174.—Twig of Ash. Note form of twig, straight, rather flattened, buds small, black, opposite.

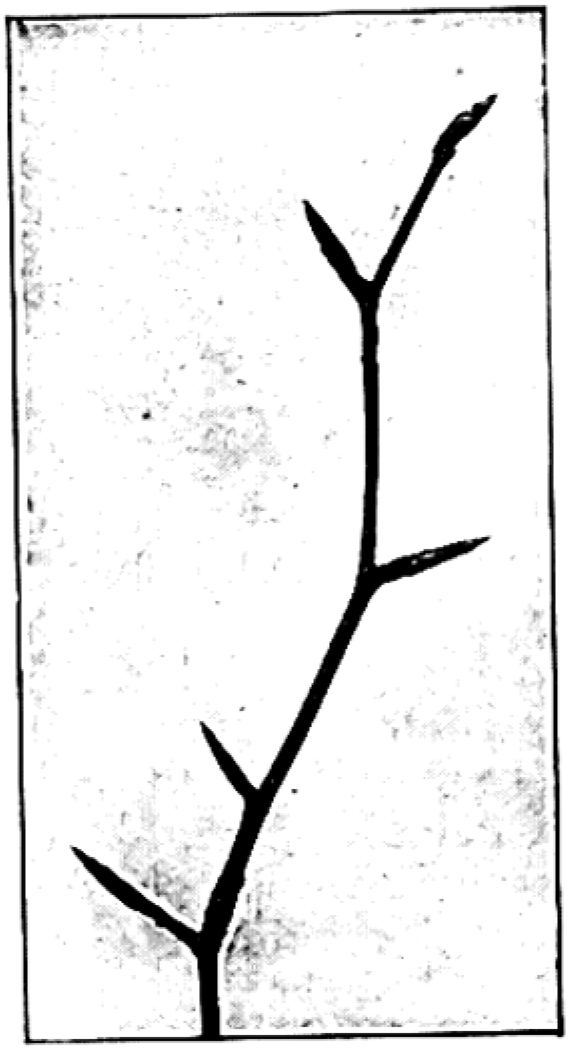

Fig. 175.—Twig of Beech in winter. Form is cylindrical, slender, angled, not straight; buds at angles, long and tapering, alternate; ring scars well marked.

You must learn to recognise many different kinds of twigs. They are interesting because although all possess many features in common, such as those we have been looking at, each has some quite distinctive features. Be able to tell at sight the following twigs: ash, horse chestnut, sycamore, lime, elm, beech, birch, black poplar, bird-cherry, gean* (Figs. 173 to 176).

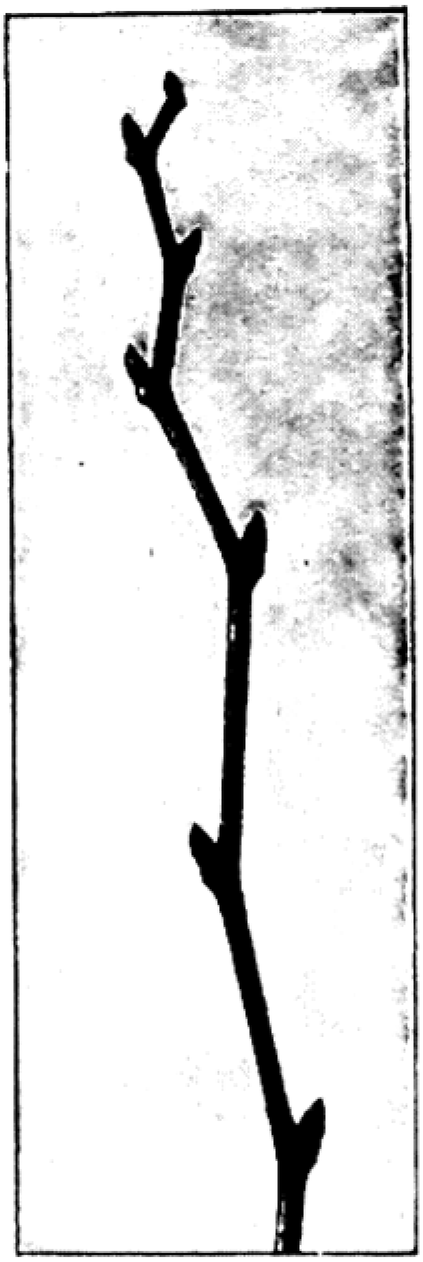
Fig. 176.—Twig of Elm in Winter. Form is cylindrical, firm, angled; buds not large, placed at angles, alternate.

Write descriptions of some twigs, under the following heads:—

Season examined:

General habit of twig, *i.e.* diameter; slender, stout, straight, angled, smooth, rough, or downy; colour; odour, if any; etc.

Markings on bark, *i.e.* **lenticels,** longitudinal or transverse, large, small; **leaf scars,** size, shape, arrangement (opposite, alternate, close, far apart); **ring scars,** distance apart; etc.

Buds. Size, shape, colour, and any other distinctive feature. **Dormant** buds.

In your study of the twigs, do not forget to continue your interest in the trees themselves in the winter as well as at other times of the year.

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* The teacher will find a very full diagnostic table of the appearance of tree twigs in winter in *Agricultural Botany*, by John Percival.

LESSON LXVII.

HOLLY AND MISTLETOE.

HOLLY.

[For a lesson about Christmas time have some holly sprigs with "berries." Tell the pupils where they may see a holly tree with the features referred to below.]

Introduction.—Here is a small sprig of holly cut from a holly tree. It is interesting to us at this season because in so many places it is put to purposes of decoration and used as an emblem of good wishes. The custom of using holly in this way is a very old one, and no one is quite sure exactly when or how it arose. But that does not matter now. We have learned to like the holly and to look upon it with pleasure at this season of the year.

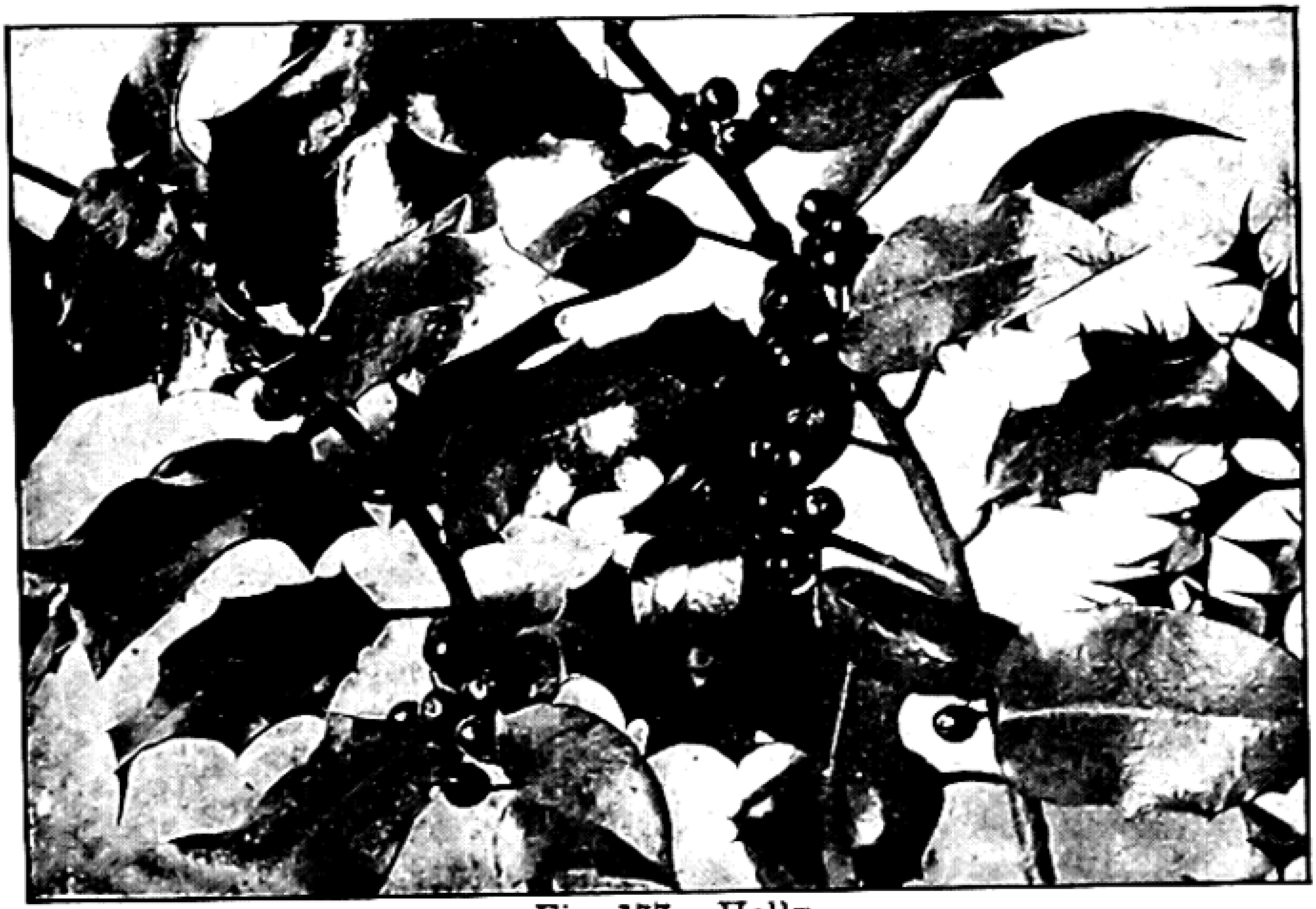

Fig. 177.—Holly.

The holly is specially attractive because it is decked with bright scarlet "berries," and there is a fine gloss upon its leaves. These things make it fresh-looking and suggest warmth, which is not unwelcome in frosty cold weather.

Can you draw this holly sprig? Do so if you can; if not, you can draw a leaf and a "berry."

The Wood.—Examine the cut end of the twig. What is the colour of the wood? It is very white, and you will also find it very hard. Try to press a pin into the end. The holly is a slow-growing tree and its wood is very dense.

What is the colour and general appearance of the bark? It is dark green and smooth. Strip off a piece. Touch the inner side. What do you find? It is sticky, though not so much so in winter as in summer.

The sap of the holly is sticky. This is the substance which is used in the preparation of "bird lime."

Leaves.—Now look at the **leaves.** The colour will to some extent depend upon the variety of holly which you have got. The green upon them is a **dark green** usually, and especially so in the winter. This is partly because in cold weather the green colouring matter is drawn away down from the surface.

What is the texture of the holly leaf? It is very tough and leathery. Can you think of a reason why holly leaves need to be more tough than those of most other trees? Because they remain on the tree throughout the winter. The holly is an **evergreen.** Is there any difference in the texture of the holly leaf in winter as compared with summer? It is **thicker** and also **more glossy** in winter. Have you noticed that? Indeed, very important changes take place in the holly leaf, fitting it to resist the weather in winter. If you could see a section through the leaf you would discover that the layer upon the outside (*cuticle*) is greatly thickened. Besides this various other changes have taken place the result of which is to lessen the amount of water passing off by the leaves, which is always important in winter.

Can you think of a real advantage which the glossy surface gives to the holly tree? It makes the leaves very slippery, so that snow slides off whenever it begins to have any weight. This avoids the possible breaking of the branches.

The spines upon the leaves are probably useful in protecting the tree from being eaten by animals. Have you noticed that the leaves upon the upper branches of a tall holly are frequently not spiny? They are beyond the reach of animals and there is in their case no need for spines.

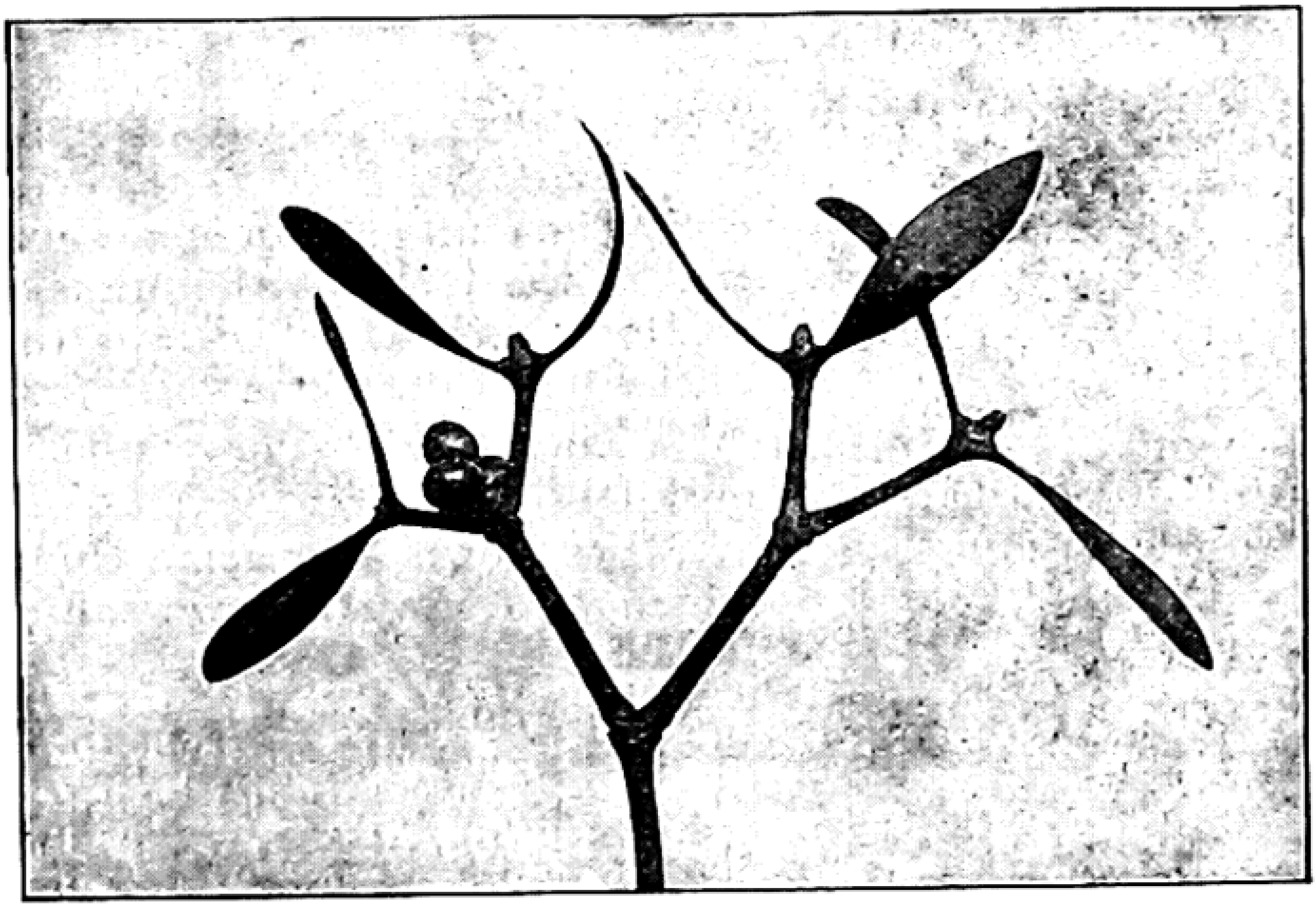

Fig. 178.—Mistletoe.

Holly Fruit.—Examine a holly "berry." It is bright red and somewhat pulpy within. Besides the pulp do you find four hard stony bodies? These are not seeds, for if you break them you will find a seed within each. The holly fruit is thus not a true berry, but a **stone fruit** with four "stones" in it. Do you remember the name of a stone fruit? It is a **drupe.**

Do all holly trees bear fruits? No, in some cases even though the tree bears flowers it may be impossible for it to bear fruit. Can you think why this is so? It is because the flowers on such a tree bear stamens but not carpels. That is they are male flowers. Other trees have flowers with carpels, and others again bear both kinds.

MISTLETOE.

Let us look at the mistletoe, which is also of special interest at this season.

Write down some peculiarities this plant has which you **observe now** (Fig. 178).

1. The colour is light green.

2. The leaves are in pairs, leathery in texture, smooth, and similar on both surfaces.

3. The fruits are in small clusters in the forks of the branches —white **berries** which are very sticky when broken.

4. There is a single seed in each fruit.

Write down also some things which you **may have seen or heard.**

5. The mistletoe does not grow in the ground, but upon another tree, such as poplar, apple, hawthorn, and others. What is a plant termed which lives upon another, drawing nourishment from it? Such a plant is a **parasite.**

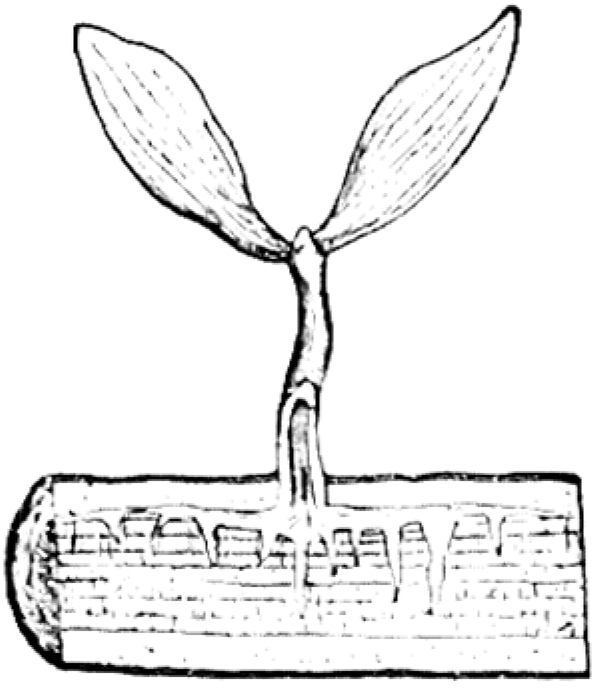

Fig. 179.—Young Mistletoe Plant.

The twig of the host tree is sectioned to show the continuous growth of both.

6. Birds leave the seeds of the mistletoe upon branches of trees, and there they take root. The birds peck the fruits, but the sticky seeds adhere to their bills. They wipe their bills upon the branches and leave the seed adhering. When the seed germinates, the young root (radicle) forms a fixing disc for the plant, and from it suckers penetrate into the tree, the result of which is that the wood of the two becomes continuous (Fig. 179).

7. The mistletoe draws off from its **host** tree the food which it otherwise would have to gather for itself from the soil. But

8. Its leaves make food with the help of sunlight like ordinary green leaves. Thus it does not draw the whole of its food from the host tree. It is therefore only a **partial parasite.**

Make a drawing of a small piece of mistletoe.

LESSON LXVIII.

AN ORANGE.

[This is a fruit we are particularly familiar with in winter. It is imported into this country from Spain, Italy, Turkey in Asia, and the West Indies. It is also grown in greenhouses at home. The orange tree appears to be a Chinese plant originally.]

Sensory Impressions.—There are several varieties (species) of orange to be obtained (p. 390); let us take for our lesson one of the commonest. We shall begin by asking a few very simple questions. When I think of the word "orange" it brings to my mind in particular four quite clear impressions. What are they? I am sure you can tell. Is not an orange to all of us—

1. A quite definite **colour.** What is this colour? We have no other name for it but orange. It is one of the colours we see in a rainbow, or in a spectrum produced by a glass prism. Can you tell the order of the colours, or where "orange" comes in the series? If you cannot, you must look for it in the first rainbow that you see.

2. A characteristic **odour.** We shall see presently the particular cause of this smell. But we notice that just as this colour falling upon the eye recalls the object, so here the smell brings it to our minds at once. Both colour and smell say "orange" to us, and not anything else.

3. A distinctive **shape** and **surface.** Have you ever tried to tell the names of things by handling them blindfold? That is appealing to your sense of touch. Does not the orange appeal in a very peculiar way to our hands, just as it does to our eyes and nostrils. Close your eyes and handle an orange. If you can handle it behind your back it will be even better than doing it blindfold, because then you are less likely to feel the smell.

Can you find words to say what you feel? Is it not something like this? The orange feels **cold.** Then the skin is **firm,** but the object is **not hard,** like an apple for instance. The surface does not feel rough, except in some kinds or at the top around the depression. An ordinary orange has a certain feeling of **slipperiness,** and yet it is not smooth. Then we notice also its shape as we handle it in this way. It is roughly **spherical,** but at the lower end an orange is rather flat, with sometimes a slight pit in the centre, while at the top it is less flat and with a deeper and larger pit in the middle.

4. The orange **taste.** This also is markedly distinctive, and agreeable to most people.

No doubt other fruits appeal to our senses in a somewhat similar way; the orange, however, in a quite pronounced way. Some children have a fifth impression—or association with the orange. It suggests a time of festivities—Christmas time.

Examination of the Orange.—Now we shall examine the orange more closely. Have you been able to distinguish the upper from the under side? You remember, of course, that a fruit always has some very definite association with the flower. Do you see any traces of the flower about the orange? Yes, you observe the shrunken remains of the calyx at the lower end and the withered traces of the flower style at the other. How did this fruit grow with relation to the part of the flower? We have just noted that the **calyx is below the fruit.** This fruit is really the ovary altered for the purpose of effecting the distribution of the seeds. Can you see any clear traces of the separate carpels on this fruit? No clear trace unless the small ridges which we sometimes see on the rind around the calyx remains are such. In the apple we can very often see quite clearly traces in the form of five "bumps" of the five carpels which are involved in the fruit (p. 274).

Examine the rind for a moment. What are the small glassy-like dots? These are small cavities (glandular) containing an oil. Squeeze the rind. What emerges from these glands? Drops of an (ethereal) **oil,** which you will find burns if squeezed into a candle flame. This oil gives the orange its characteristic smell.

Now cut the orange across about the middle horizontally. Make a drawing of what is to be seen. Can we name all the parts? The outside skin with the oil glands is the **epicarp,** the white substance is the middle layer or **mesocarp,** and the inner membrane bounding the segments of the orange is the **endocarp.** Compare these three layers with what you find in a plum or cherry. We have not yet spoken of the juicy tufts within the segments. What are these? A study of the growth of an orange shows these to be grown from hairs which line the walls of the chambers of the ovary. These hairs swell up with juice until in the ripe fruit all the space around the seeds is quite filled up.

Such a fruit our section shows us is made up of a number of carpels. In the cultivated trees the number of carpels varies.

An Orange is a Berry.—How do we describe a fruit like this? It is a **berry.** Compare with others, such as gooseberry, tomato, currant. Examine the **seeds.** Describe their appearance. They are white, rounded, with pointed ends, hard, and slippery. Open one by cutting lengthwise. You will see two seed coats, a food store, and **more than one embryo** plant usually. If you have a good lens, examine an embryo minutely and draw it.

LESSON LXIX.

CHRISTMAS ROSES (*Helleborus niger*).

[There are several varieties of Christmas roses grown in gardens. Specimen plants can always be had from nurseries. One entire plant should be available if possible for the purposes of this lesson. Such may be hired, and cut flowers can without much difficulty be obtained at this season.]

Attractions.—What are the special features of interest which make this flower attractive to us? There are, I think, two. The flower is a pretty one. The one I am looking at is beautifully white with rich tracings of pink on the outside. There is a mass of rich yellow in the centre, through which points of green are visible. The whole flower looks refined and delicate. There is further the added interest that the Christmas rose flowers in winter, when plants in flower are scarce out of doors.

It thus appears to belong to a hardy family. The garden plant we are studying is not a native of Britain, but of the South-eastern Alps. We have, however, two related native species occurring in the South of England, viz. the stinking hellebore and the green hellebore, and both of these flower early in the year, the former in January and February and the latter in March.

Examination.—Let us examine the Christmas rose. It is not a simple flower. We are familiar with the usual parts of a flower, viz. sepals, petals, stamens, and carpels; let us look for these in the Christmas rose. In this case it will be simplest to look first at the centre of the flower. Let us write down what we see (Fig. 180).

1. Several **carpels,** which are separate from each other. In shape they will be seen to resemble pods with their ends drawn out. They should also be examined in a flower in which the fruit has formed. Remove and draw one.

2. A large number of **stamens.** The anthers of those to the outside will probably be seen to be open and shedding the pollen, whilst those towards the centre of the flower are still closed.

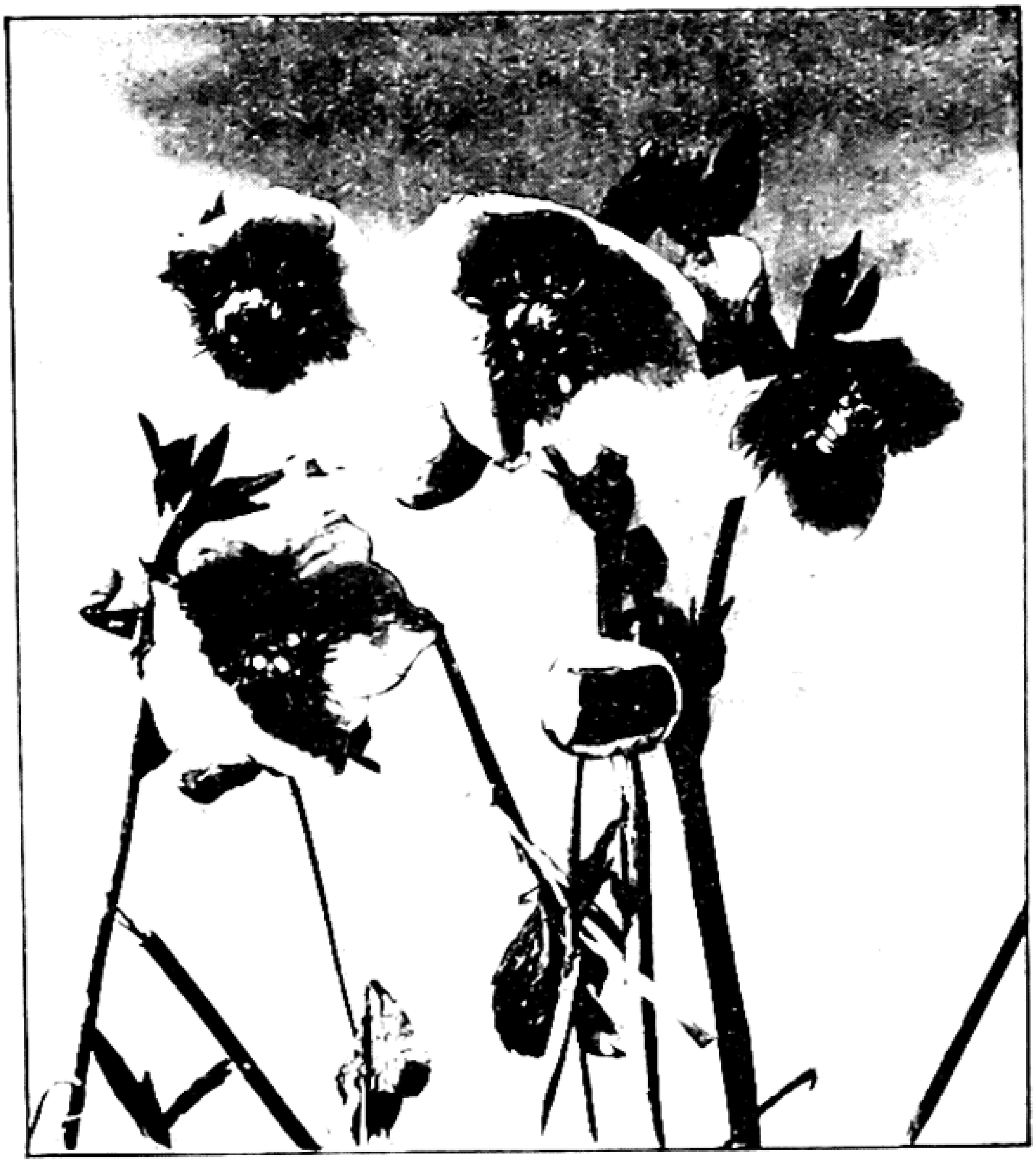

Fig. 180.—Christmas Roses.

3. A number of **trumpet-like tubes** forming a ring around the stamens. What are these?

If we could watch insects visiting this flower, we would find that these tubes are the parts in which they find the nectar. We find, besides, that the honey is so abundant that when we open one of the tubes it flows out. You must verify this for yourselves. These tubes are **nectaries.** That is, they are parts of the plant whose work it is to produce sweet substances. Now we have already learned that they may occur in various places within a flower, but it should not be too difficult for us to make out from what part of the flower they have been formed in this case. We may recall, for instance, that we have seen the nectaries on the inside of the petal of a buttercup, and also that these nectaries here are in the same position in the flower as petals ordinarily occur. After we have thought for a little about these things we will understand that in the Christmas rose the petals have been changed into honey-making organs, viz. nectaries. Compare monkshood (p. 244).

4. Five large **white petal-like parts.** But some of you may say—if these nectaries are the petals—What are these five large beautiful white parts resembling petals which surround the nectaries? Well, if you look you will see that these form the outermost ring of parts in this flower. These are the **sepals.**

The sepals of this flower we see have taken the form of petals (petaloid). While the flower is in bud they protect the other parts and hold them together. This is the work of sepals. But when the flower is expanded, by their size and beautiful colour they make it attractive. They are then acting as petals, but we see that, although this is so, they are really sepals. Other flowers whose sepals do the same thing are the wood anemone, the globe flower, and the monkshood (pp. 6, 244).

Later Stage of Flower.—Notice that the flower is without smell. Another thing which will help us to understand the real nature of the parts of this flower is the appearance when the fruit has been formed. The flower should certainly be examined at this stage. What do we find? The nectaries have gone, the stamens have withered and fallen away. The carpels are present, of course, because they contain the seed. So also are the sepals, but notice how they have changed. So far from falling away or persisting in a withered state as is usually the case, they are actually firmer and stronger, and are now **green in colour,** spreading out broadly to the sunlight and doing the work of ordinary leaves. Although sepals do not ordinarily persist after the flower is faded, they are green, and while they remain on the flower they can act as ordinary green leaves.

In this flower the stigmas are mature before the stamens. When the flower opens the stamens bend outward over the nectaries. If then the insect has previously visited a more mature flower in which the stamens are shedding their pollen its body will carry some pollen to the stigmas of the next flower. In flowers at this stage the ripe stamens have elongated filaments which bend outward so that the anthers hang over the nectaries and thus are brushed by the insects' bodies.

When the stigmas have been pollinated they bend backward and stand more or less erect in the centre of the flower.

The Plant not a Rose.—Is this flower really a rose? Does it recall the wild roses of our hedges? In general appearance, perhaps, it resembles one slightly. But this resemblance is not a very complete one, and there is really no good reason why we should compare this flower to a rose at all. In the parts of which it is made up it more nearly resembles a buttercup, and indeed belongs to the same family.

Leaves and Underground Stem.—Leaving the flower, we may glance briefly at some of the other parts of the plant. Sketch a leaf—note its greatly divided blade. Note the alternate arrangement. Notice also the underground creeping stem from which the roots arise.

LESSON LXX.

THE SNOWDROP (*Galanthus nivalis*).

[The pupils should each be supplied with specimens.]

Appreciation.—We have here some snowdrops freshly gathered. Let us ask some questions about them as we look at them and enjoy their beauty. What are the things about snowdrops which are specially pleasing to us? First, they are very welcome because they flower before the winter is over. Flowers are amongst the things which give us pleasure; we have not many flowers growing in the open in winter, and so we are always glad to see them. A second thing about snowdrops is their attractive appearance. Look at the snowdrop closely. The general effect of the white colour along with the bands and fine delicate lines of green is very pleasing. The shape and drooping position too, as well as the small size of the flower, are things which we also notice help to make up the attractions of this flower.

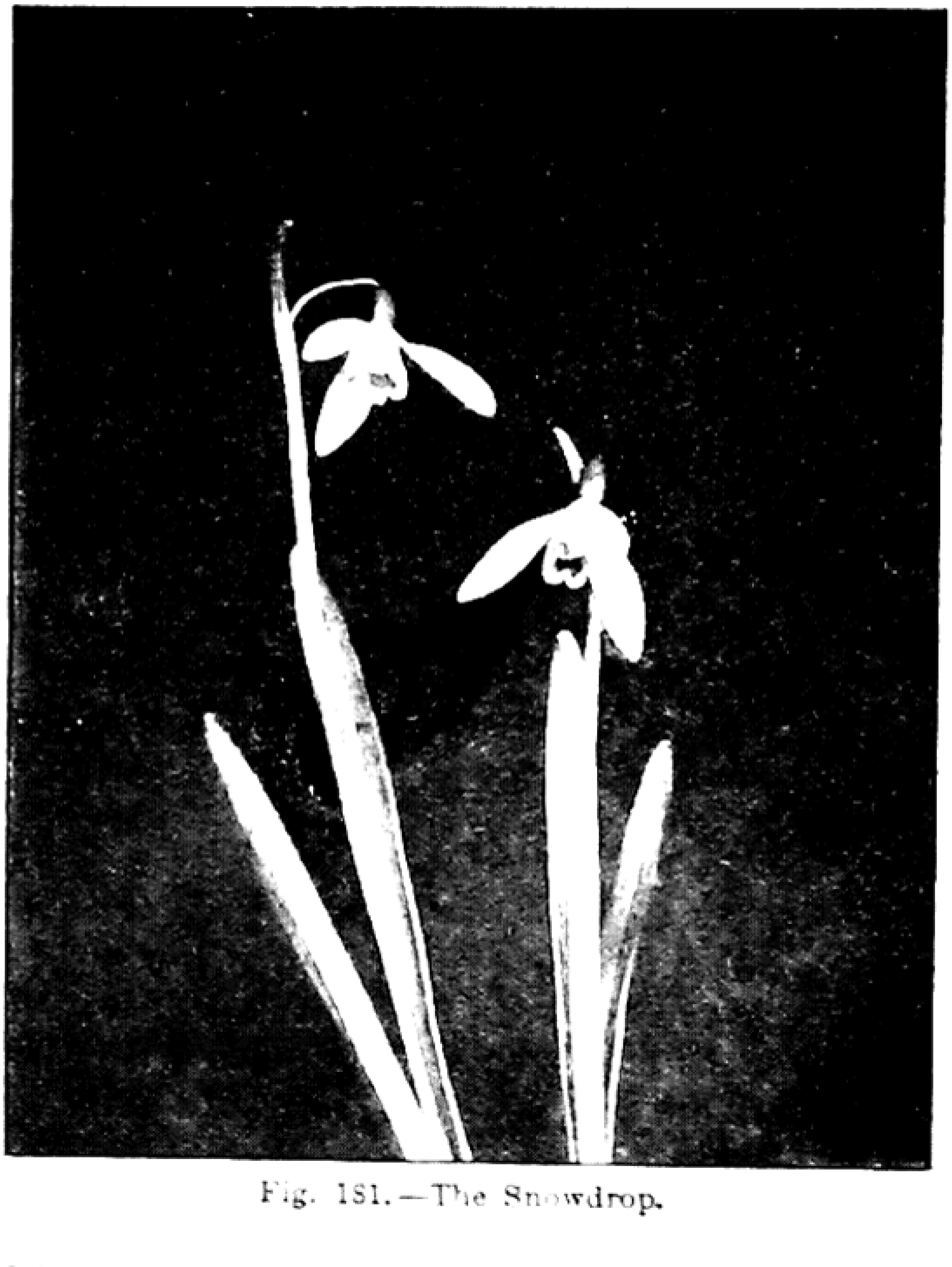

Fig. 181.—The Snowdrop.

A Drawing of the Flower.—Before we go on to speak of the separate parts in detail you should draw the flower, noticing how all these things we have spoken of, viz. its colours, shape, and attitude upon the plant help to make it a pleasing flower to look at or to think about. After you have drawn it thoughtfully, try to put into words what you think it is like. It is a fragile or tender flower, delicately coloured, suggestive of purity with its whiteness, humility in its drooping head and lowly stature. But you must find your own words for what you feel.

Detailed Examination.—Having drawn a snowdrop plant you will now be able to say what parts are present in this flower and what the arrangements are. The attracting part consists of a **perianth** made up of two groups, different in shape, of three white parts (cf. sepals and petals), two groups of stamens, three in each, and a centrally placed style, arising from the ovary, the small green cup-shaped basal part of the flower. Cut through the ovary and notice that it has three chambers, with three sets of ovules (possible seeds). In sunshine the sepals (outer ring of perianth) diverge so that the green lines upon the petals are made more visible. These lines are honey-forming regions (= nectaries), and in sunny weather honey bees visit the snowdrops, collecting both pollen and nectar. Perhaps you will be able to notice that the anthers open near the top. If bees fail to visit there is always the possibility that pollen will fall on the stigma, owing to the drooping position of the flower, and **self-pollination** thus takes place.

If you compare the parts and their arrangement in the snowdrop with the same in the narcissus and daffodil which you examined in the spring you will find that they are very similar. There is no corona in the snowdrop, that is the most important difference. These three plants belong to the same family (Natural Order) of flowering plants (p. 59).

A characteristic part of the snowdrop is the **erect sheath,** partly green and partly membranous, which stands up behind the drooping flower. What is the use of this part?

What are the parts of a complete snowdrop **plant?** Besides the flower and its stalk and protecting sheath there are **two green leaves,** slender in form and rather blunt at the tip. At the base, underground, there is a **bulb** from the under side of which roots arise. In another lesson you have learned what a bulb is and what use it serves (p. 354).

NOTES UPON SOME OF THE PLANTS CONSIDERED IN THIS CHAPTER.

The characters of the Natural Orders are either given elsewhere, or these are only sparsely represented in Britain.

Helleborus niger, **Christmas Rose.**—As indicated in the text this plant is a member of the Order Ranunculaceae. Its general structure has also been considered. The fruit consists of a cluster of follicles (p. 247).

Viscum album, **Mistletoe.**—The mistletoe belongs to the Natural Order Loranthaceae. It flowers in March. The flowers occur in clusters, are minute and unisexual. Staminate and pistillate flowers on separate plants.

Ilex aquifolium, **Holly.**—Order Aquifoliaceae. The holly flowers in May. Its flowers are small, white, clustered. Fruit from September onwards. There are various garden varieties, the most familiar being the variegated, with white and yellow leaves, and one with smooth-edged leaves—the unarmed variety. The wood, owing to its hardness and fine grain, is valued for inlaying and cabinet-making work.

Citrus vulgaris, **Orange.**—Order Rutaceae. All the members of this order contain oil cavities. The lemon (*Citrus limonum*) is a related species. There are three familar forms of orange to be had in this country—the so-called common orange, of which several varieties exist; blood oranges, from Malta or Portugal, with purplish "flesh"; and Tangerene or Mandarin oranges. "The name orange, which is introduced into many languages and is derived from the Sanscrit word *Nagarunga*, points to the ancient cultivation of the plant in India" (Strasburger).

Galanthus nivalis, **Snowdrop.**—Order Amaryllidaceae (see p. 59).

Pinus sylvestris, **Scots Pine**; *Picea excelsa*, **Spruce Fir**; *Larix europaeus*, **Larch.**—These are examples of Coniferae, a group of gymnospermous (or naked seeded) plants. The seeds are borne exposed upon the scales of the cone. Compare this arrangement with the closed carpels in angiospermous plants. The scales which bear the ovules are regarded as being of the nature of a large **placenta.** Beneath these scales there are to be seen in the young cone so-called "bract scales," on the surface of which the larger ovule-bearing scales arise. The bract scales are regarded as equivalent to the carpels (Fig. 169).

Toadstools and Mushrooms.—These are *Fungi* belonging to the group Hymenomycetes. For their place in the general classification see p. 465. Most members of this group structurally resemble toadstools. They mostly live upon decaying vegetation, *i.e.* are saprophytes. The reproductive bodies known as conidia arise upon the gills, as stated in the text, and are asexual in origin. No sex processes occur in this group of plants.

QUESTIONS ON CHAPTER VII.

(WINTER PLANT STUDIES.)

1. Make a drawing of a toadstool, and name the principal parts.

2. What important difference is there in the mode of feeding in a mushroom as compared with a green plant? What are "fairy rings"?

3. Give two examples each of plants possessing a rhizome, a corm, and a bulb. Give a sketch of a corm and name the various parts usually visible upon it.

4. What is the nature of an ordinary potato? What are the "eyes," and what do they give rise to?

5. State some of the ways in which the more delicate parts of trees are protected against the winter.

6. Describe the appearance of a horse-chestnut twig in winter.

7. Give two examples each of trees with opposite buds, and buds spirally arranged upon the twig. How can you tell a season's growth upon a twig, *e.g.* sycamore?

8. What are the following: *Stomata, lenticels, cuticle, chlorophyll*?

9. Describe the leaves of the Scots pine, stating on what parts they arise, and their arrangement.

10. How do you distinguish the ripe cones of the Scots pine, spruce fir, and larch?

11. Compare the larch and the spruce fir in winter.

12. Describe the appearance of a piece of common coal.

13. Give a short account of the way in which coal has probably been formed.

14. What is the relation between coal and the sunlight of past ages?

15. Name a tree with angled twigs whose buds are slender and tapering. What tree has small thick black buds?

16. What are ring scars? What duration of growth is represented in the interval between two sets of ring scars?

17. What are the chief characters of a holly leaf? What is the advantage of the thick cuticle and spiny margin?

18. What kind of fruit is a holly "berry"? How is it not a true berry?

19. What is a "partial parasite"? Where does mistletoe grow? How may it be planted in such a situation?

20. Where upon an orange do you find traces of the flower? Name the parts seen in a cross section through this fruit.

21. From what structures is the "juice" of the orange formed? What is peculiar about an orange seed?

22. Describe briefly the parts of the flower in the Christmas rose. State what parts persist and in what condition after the flower is pollinated.

23. Describe the appearance of the snowdrop flower. Where is the ovary situated with reference to the perianth?

24. What is the nature of the underground parts of a snowdrop? Name other two plants of the same Order.

CHAPTER VIII.

ANIMAL STUDIES IN WINTER.

LESSON LXXI.

THE WINTER SLEEP OF ANIMALS.

Conditions in Winter affecting Animal Life.—Winter is a trying or testing time of the powers of endurance of animals. During this season there are always large numbers which are cut off; they are not able to live through it. Try for a little to think of the way in which winter affects the lives of animals. Write down shortly what the general conditions are under which our land animals live in winter?

(1) *It is* **cold.** The temperature is low on the average, and through the season there are from time to time days or nights of very great cold, so severe that at one sweep, as it were, many creatures are chilled to death. They fall asleep and never awake. The cold is a great tester of the powers of endurance of animals. But cold also indirectly affects the lives of animals. Thus:

(2) *It brings* **snow,** and also hardens the earth with frost. And when the earth is covered or frozen hard, the food supply of most land animals is cut off. This means then—winter is a time of scarcity, and many die from hunger as well as from cold.

(3) In winter, too, the **day is shorter**—there is less light during which food can be searched for. There is no doubt this adds to the severity of the winter trials of animals, especially birds.

These trying conditions are met in different ways by different kinds of animals. Some do not remain where the cold and scarcity of food are, but migrate longer or shorter distances, such as most of our birds. To a few the winter is made easier by a whitening of their coats, such as the stoat and the ptarmigan; others make the winter life possible by putting by in the autumn a store of food for its use, such as squirrels and hive bees; some struggle through it the best way they can, making no specially noticeable provision.

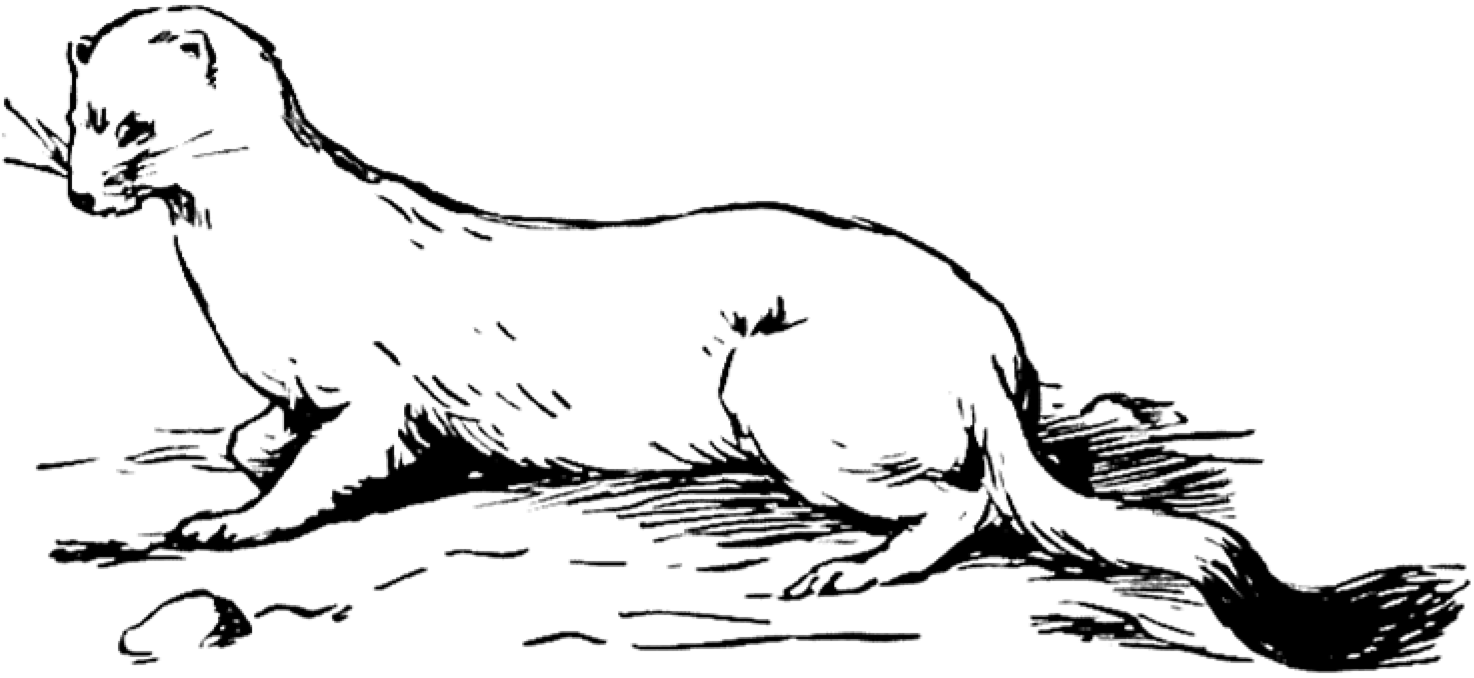

Fig. 182.—The Stoat in its winter coat. Note that the tip of the tail does not turn white as the rest of the body does.

Hibernators.—Besides these, there are a good many who solve the problem by going to sleep. Do you not agree that this seems the easiest and the safest way? Can you name any animals which sleep more or less through the winter? Write down a list of these. Of higher animals, those best known to us are the **bats,** the **hedgehog,** the **dormouse,** the **squirrel,** the **field vole.** Then there are **snakes, lizards, tortoises, frogs,** and **toads;** and, amongst lower animal types, **snails** and **slugs,** and many **insects** also pass the winter in sleep. This is not a very long list, you see, although some others might be added to it. We must not forget, too, that most animals sleep more in winter than they do at other times.

The winter sleep of some of these is not very difficult to understand. At no time are slugs and snails or tortoises very active, and cold alone seems sufficient to render them dormant. Very few insects exist in an active stage in winter, and all those animals which feed on them, such as frogs and toads and lizards, find food so scarce that they need not go about in search for it. It is not to be found, and so they rest in quiet until it becomes more abundant. Many of the animals which snakes feed upon, such as frogs, mice, and insects, are lying in concealment, and so for them also the finding of food in winter is difficult and they also sleep. Do you not see then how the life of one kind of animal affects the lives of others, and how the question of food has much to do with the winter sleeping habit? But note also what is said below regarding bats.

All of these animals are what is termed cold-blooded. Their bodies are never very warm, and the cold does not really affect them so seriously. But you may ask: How is it that they do not die in winter for want of food? The answer is partly because as they are not moving about they need food less, and in the cold their hearts beat slower, they breathe slower, and there is very little waste going on in their bodies and so again little food is needed. Then throughout the rest of the year they never lose an opportunity of feeding, and they mostly commence the winter in a fat condition. This fat serves to keep them living—giving heat and food during the winter sleep. No doubt there are always some which never waken, and these are just the ones which are not so well provided against winter as those which live through it.

Winter Sleep of Mammals.—The winter sleep of mammals, whose bodies are warm, is brought about in much the same way, only you will see that it is not so easy for them as they require their bodies warmer while they sleep. This is helped in part by their fur growing thicker and longer, as in the case of the squirrel, or by their covering themselves with leaves and the like, forming a kind of nest such as the hedgehog makes. Practically

all mammals sleep a good deal in winter, and of the active period during winter there are grades to the deep continuous sleep of the true hibernator. For example, there are some sleepers which lay past a store of food as well, and these wake up now and again, feed, and go to sleep again. Such are the **squirrel** and the **field vole.**

The **hedgehog** sleeps much more soundly. It remains dormant through the whole winter, rolled up in a ball and buried in a nest of leaves, moss, straw, and the like formed in a hollow tree or other natural cavity.

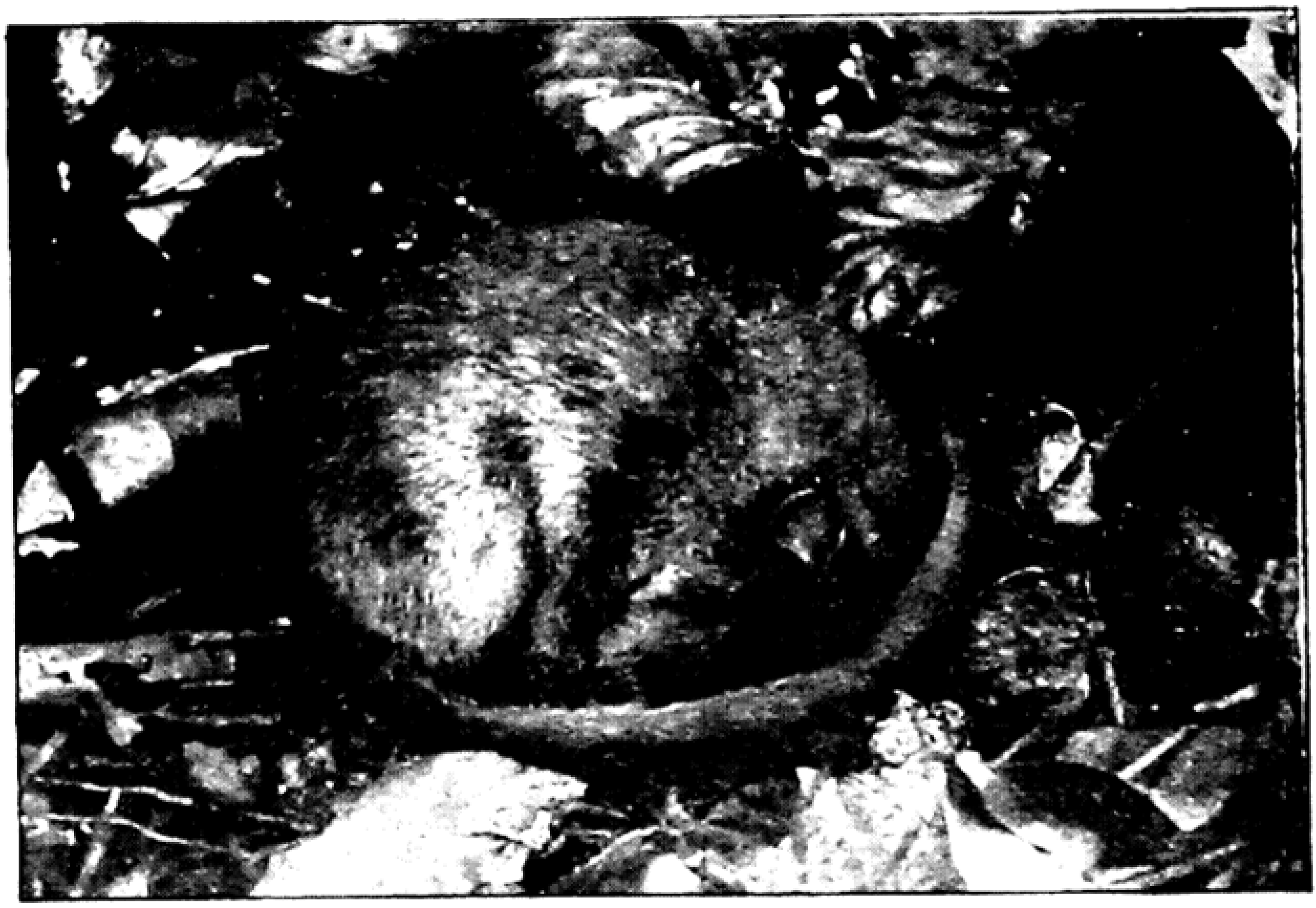

Fig. 183.—Hibernating Dormouse.

Do you know the **dormouse?** It is a little animal of habits similar to the squirrel, but living in shrubberies or hedges and very much smaller, being only a few inches long. It stores up food as the squirrel does, but also becomes exceedingly fat before winter. It forms a cosy nest within which it coils itself into a ball and passes into a deep sleep. It may, like the squirrel, awake if the weather be mild, feed from its store, and go to sleep again (Fig. 183).

Bats, from the nature of their food, viz. insects, are not able to store. They usually gather in large numbers under the roofs of houses, barns, deserted buildings, and about church towers, and hanging by the feet head downwards sleep a deep sleep through the winter. They sometimes crowd closely together, holding on to each other so as to form a thick mass. There are some rather interesting things to note about the hibernation of bats. First, it is a very deep sleep. If bats are wakened out of it, they frequently die. The sudden calling into activity of their vital organs, such as heart and lungs, puts too great a strain upon them, so that even if they go to sleep again they may not awake. For all this, when they waken naturally during winter, owing to mildness of the weather, they may take a flight in search of food and return to complete their sleep.

Some bats commence their winter sleep very early, as soon as the beginning of August in some cases. In this case it cannot be either the scarcity of food or the cold which is the immediate cause. But this illustrates the fact that although it is likely that the habit began in the past in connection with these things, it is now so much a part of the constitution of the animals that they actually go to sleep before the winter comes on, even although they do not actually feel it colder or find food scarcer. I hope you will try to understand this.

Summary.—Now let us sum up the chief things to remember about winter sleepers. Write these down :—

1. Winter sleeping is common amongst the lower animals —less common amongst warm-bodied ones. Birds are noteworthy in not engaging in this habit.

2. There are various degrees of it, from sleeping a good deal day and night in winter, which is usual ; deeper sleeping with waking times during which feeding upon stores of food takes place (squirrel, dormouse); to long and deep continuous true hibernation (bats).

3. There is preparation made for it in the autumn fattening which takes place, especially in the deeper sleepers—dormouse, hedgehog, bears, bats.

4. It usually comes on when food gets scarce and weather cold. But some bats are exceptions and hibernate before these signs of winter appear.

5. In true hibernation, as distinguished from fitful sleeping day and night, there is a slowing of heart, of breathing, and of waste of body substance. We might compare a hibernating animal to a seed, living but dormant. Only the internal activity of the hibernating animal is both greater and more evident.

6. Very different kinds of animals practise it.

LESSON LXXII.

THE BONES OF BIRDS.

[The teacher should endeavour to have a few clean bones of birds. A collection should be built up by degrees as opportunity offers. Useful bones for demonstrating some of the features of interest in the skeleton of birds are the wing bones, breast bone, back bone, and shoulder girdle. Separate lessons should be given on the various pieces of the skeleton, and the whole subsequently revised and summarised.]

Bird Bones in General.—The life of birds is so different from that of all other creatures that we expect to find their bodies showing signs of being specially suited to their habits. They do show many "adaptations," and the most interesting of these occur in the skeleton.

When we handle the bones of a bird, one peculiarity becomes noticeable. Take, say, the upper bone of the wing of a bird (humerus) or a breast bone in your hand. What impression do you get? That of **lightness.** Birds' bones are very light. Put them in water. Do they sink? No, they float. Are they brittle? No; although light, they are very **strong.** Look at their surface and you see it is shiny and very dense. Try to break a long bone such as the humerus and you find it is very difficult to do this. A bone of a mammal will snap in two more readily than that of a bird of the same size.

Fused Bones.—Another peculiarity of the bones of birds is that in many places where separate bones exist in other animals and the parts are flexible and move freely, they are in birds united together, so that these parts are stiff and rigid. This is the case in the **outermost division of the wing** (hand), in the **ankle,** and in the **backbone**. Examine these parts for yourselves. What is the advantage to a bird in having a stiff end portion to the wing, and a stiff back? Both of these things make the bird a strong flier. It is very important that the end portion of a bird's wing should be stiff, because this part carries the long outer quill feathers which have to bear much of the resistance of the air when the bird is flying. Were the support of these feathers weak or bending, much of the force of the stroke of the bird's wing would be lost.

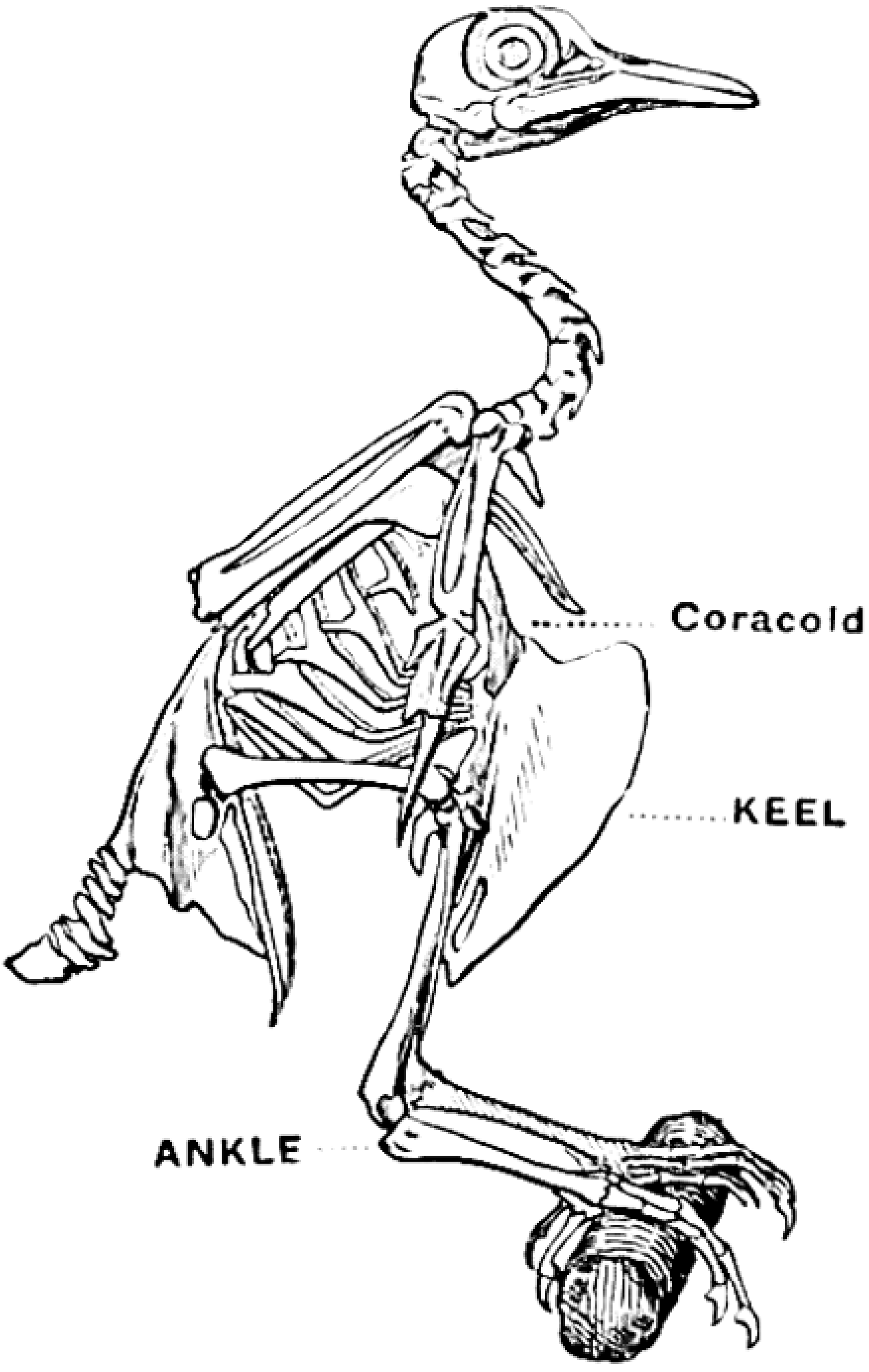

Fig. 184.—Skeleton of the Pigeon.

The stiff back bone has much the same value. It steadies the bird's body in flight and gives resistance to the wing strokes. A flexible back is a necessary thing in an animal that creeps, runs, or jumps, but a stiff back is best for flying.

The ankle of the bird has only one movement—an opening and closing one. Probably this kind of joint enables birds to **perch more securely** (Fig. 184).

The Breast Bone and Shoulder Girdle.—Make a drawing of this piece of skeleton.

In a bird this is a very important structure. What are the large masses of flesh which lie upon this bone? They are the muscles which lower and raise the wings during flying. They are the largest and heaviest muscles of the bird's body, because flying is the thing which requires the greatest amount of muscular effort on the part of a bird. The size of these muscles explains two things about the bird's breast bone, viz. its breadth, and the prominent ridge or **keel** upon it. These things give a large surface for the attachment of large muscles. It is very noteworthy that birds which never fly, *e.g.* ostriches, do not have a ridge or keel upon their breast bones. Besides giving support to the flying muscles, the breast bone **protects the soft and delicate organs,** such as the heart, which lie behind.

There are other important uses which this large bone serves. Do you see those little notches at the side of this bone? Can you think what these are for? If you have a complete trunk specimen to examine you will see that these notches receive the lower ends of the ribs, which although interrupted reach upward to the back bone. All these things simply mean **greater rigidity** to the bird's body, which makes the strokes of its wings have more effect.

Do you see the shallow groove on each side of the front end of the breast bone? Try to show this in your drawing. Do you know what this is for? The lower half of the shoulder bone rests in this groove. Look at the whole skeleton in this place and you will see this part (coracoid bone) resting in the groove. Is it a strong bone? Yes. You can see that it is firmly fixed to the narrow shoulder blade which lies along the back, above the ribs and nearly parallel to the back bone. The whole wing is attached to the body at the meeting-place of these two—upper and lower—halves of the shoulder girdle, as the entire piece is called.

Now do you not see that as the bird's wing flaps up and down it will tend to press inward upon the body at the shoulder, and that the shoulder girdle in resting upon the breast bone below is thereby greatly strengthened to resist the inward pressure of the wing, and thus make the wing stroke of more effect?

The more you look at these parts you will see how perfectly fitted together the whole thing is, and how everything tends to make the work of flying easier.

The Merry-thought Bone.—Between the shoulders and standing in front of the breast bone is a very familiar bone, known to us under different names. Perhaps the commonest of these is the "merry-thought." Another common name is the "wish-bone." You know how it is used by children in this connection. A less common name is the "furcula," which means "the little fork." Lastly it is also called the clavicle or "collar bone," since it compares in position and use with the collar bone in other creatures. In some birds the angle between the two limbs of this bone is very narrow, in others the limbs are united roundly, forming a U shape.

The Back Bone.—There are two striking and easily noted features about a bird's back bone. One of these is the extreme rigidity of its trunk portion. We have already noted the meaning and value of this. The other feature contrasts greatly with this—it is the remarkable length and flexibility of the neck portion. In looking at any ordinary bird, we are apt to be deceived as to its internal make-up by the plumage, which greatly alters its form. Perhaps with regard to no part are we more likely to be misled than with the neck. A duck, for example, has a neck which is about as long as all the rest of its back bone. So have most birds.

Watch the use a bird must make of its bill and you will see both how necessary and how valuable the long neck is. The fore limb of the bird is the wing, and it can only be used for flying. The bill has to do many things which otherwise might be done by the fore limbs. Because of the long neck the bill can reach any part of the trunk, wings, or legs, preening the feathers, removing parasites from the skin, and so on.

Make drawings of as many separate bones as possible. Try to understand what you observe in the light of the flying habits of birds.

LESSON LXXIII.

THE WING OF A BIRD.

[The wing of any flying bird may be used for the purpose of this lesson. Whilst this is so, there is no doubt that more effective point will be given if a wing of a fine flyer, rather than, say, that of a barn-yard fowl, be the object used. Fresh wings may be used, or permanent preparations dried and stiffened in the expanded position.]

The power of flight is one of the fascinations of bird life. Mankind has long envied the birds this power. There are many things about them which must be considered before we can understand how they are able to fly. The wing is one of these which is very important in connection with flight, since this is the part of the bird which supports it in the air and drives it forward.

The Parts of the Wing.—Let us look at the wings of a bird.

Here is the wing of a pigeon. A pigeon is a strong active flyer. You must examine the wings carefully, and notice the following:—

1. The wing is very **light.** Feel the weight of it in your hand. For the size, a pigeon is a fairly heavy bird, and its wings are remarkably light in proportion. This is

none the less remarkable when we remember that they contain some very strong bones, as we shall see.

2. The **stretch** of the spread-out wing. If you measure a wood pigeon from one wing tip to the other you will find the stretch is about 33 inches. The width of the body is only about 3½, so that there are 29½ inches of wing stretch. If you watch the crows, gulls, and other birds flying overhead you will see that a large stretch of wing is a common feature. Some birds have narrow wings and some have broad; but short wings in flying birds are rare, and their owners are poor fliers.

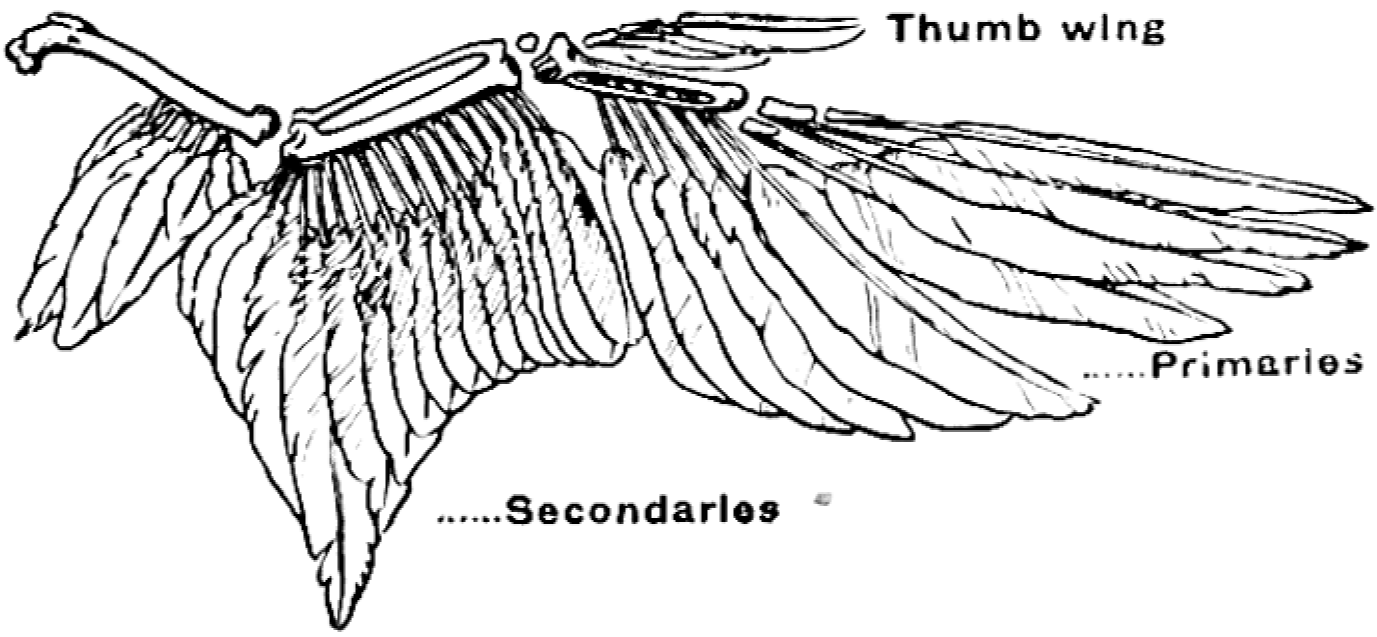

Fig. 185.—The wing of the Pigeon, showing the bones and the principal feathers The coverts have been removed.

3. The **area** of the wing is made up mostly of feathers. The fleshy part of the wing is quite narrow. This makes the wing very light for the size of it.

4. **Resistance.**—The wing offers a firm resistance to the air. Move the wing quickly through the air and you will feel this. The structure of the feathers, especially the quills, which are light but firm, and hold together when striking the air evenly, gives the same character to the whole wing.

5. **Strength.**—The wing is thickest and strongest along the front edge. This is very useful to the bird, for it prevents the front edge tilting up when the bird is flying.

The same kind of thing may be noticed in the quill feathers nearest the tip of the wing. Their shaft is placed nearer one side, viz. that side which is towards the front of the wing.

6. **Shape.**—The wing is slightly hollow on the under side. This helps in the same way, preventing tilting. It also enables the wing to lie closely to the body when it is folded down.

7. **Folding.**—The wing folds in three divisions, arranged like the limbs in the letter Z. Feel these divisions carefully. Within each you can feel the supporting bone or bones. These three divisions correspond to our upper arm (shoulder to elbow), lower arm (elbow to wrist), hand (wrist to finger tips). Go over them again and try to make out—

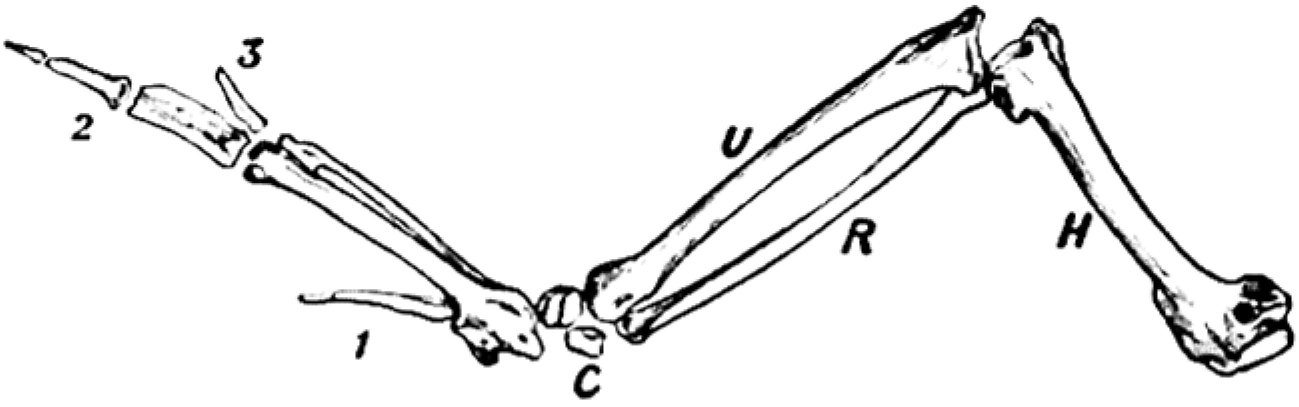

Fig. 186.—The bones of a bird's wing.

H, Humerus; *R*, Radius; *U*, Ulna, it supports the secondary quill feathers; *C*, Carpus, of which there are only two free elements, the remainder having fused with the fingers; 1, 2, 3, Bones of the fingers.

(*a*) the single bone in the upper arm, the humerus;
(*b*) the two long bones in the lower arm, radius and ulna;
(*c*) the stiff unbending hand;
(*d*) the "thumb," which stands out separately on the front edge of the hand and has a separate tuft of feathers upon it, digit No. 1;
(*e*) the fold of skin stretching across the bend of the elbow joint (Fig. 186).

8. **Feather Groups.**—The different groups of feathers:
(*a*) Quills upon the "hand"; these are called "primaries."

They are mostly narrower along their front edge than along their hind edge (Fig. 185).

(*b*) Quills upon the lower arm; these are more regular in shape. They are called "secondaries" (Fig. 185).

(*c*) Smaller covering feathers above and below the wing and hiding the quills of the long feathers, the coverts.

(*d*) The thumb tuft.

Feel again the bones of the lower arm. Which is the stronger? The one nearer the quill feathers. Why is this? It supports the strong quill feathers (secondaries). Why is the hand stiff? Because this kind of hand is more useful for striking the air with than a jointed one.

Why is the hand so narrow? Because it allows the wing to fold up more closely when the bird is not flying.

Make a careful drawing of the extended wing, and name the different kinds of feathers.

Outdoor Observations.—Watch birds on the wing, and notice the shape of the wing in the following:—Swallow, swift, rook, gull, and any others you can observe closely.

A separate lesson upon the different kinds of feathers should also be given. This should include drawings of primary, secondary and other feathers with demonstration of the way the various parts are related to each other and their uses. Full particulars will be found in *Aims and Methods of Nature Study*, pp. 98, 103.

LESSON LXXIV.

THE REDBREAST (*Erithacus rubecula*).

[The lesson will probably be most appropriately taught when snow is on the ground. The winter habits of this bird will then be more readily realised.]

The redbreast is without doubt the bird of greatest interest around our homes in winter. You are all more or less familiar with its appearance. Let us recall those features of which you have a clear recollection. You must write these down.

Appearance.—First of all there is of course the red breast. Have you noted the extent of this patch of colour? The so-called red breast extends not only over the fore part of the breast, but also the neck, round the sides of the head, and the front part of the forehead at the back of the bill. Did you know it spread so far? It is a yellowish red. The colour of the breast has a highly decorative effect, and gives the bird a look of smartness and freshness. There is no doubt the appearance of the robin as far as his foreparts go has something to do with our liking for this bird.

An interesting question is the coloration of the hen bird, and you should try to verify the facts for yourselves. Many people say the hen robin has not got a red breast. This is not correct. She is very similar in size and general appearance to the cock, only the red on the neck is rather paler, and the back more grey. If the winter is stormy and you feed the birds in the garden you are sure to get a chance of a close view of both cock and hen. Do not miss an opportunity of doing this.

Next to the red breast, what other feature of a pleasing nature attracts your attention. The robin's eye. This looks large and bright. It is of moderate size, but looks big for so small a bird. It is of a bright black colour, and gives its possessor an alert appearance. Observe the robin's eye when next you see one.

Movements.—What are your impressions of its movements? Its behaviour on the ground is not unlike that of the thrush. With tail horizontal, and wings slightly drooping, it hops, stands still, and again hops forward with a little rush. In the air it goes with a rapid, low, direct, and sometimes a rising and falling (undulating) flight.

Disposition.—The disposition of this bird, coupled with its attractive appearance, has led to its being a general favourite. What character do you give this bird? It is interesting to hear other people's descriptions. Some lay stress upon its assertive character and describe it as bold, quarrelsome, pugnacious, domineering. There is an element of all these features in this "cocky" little bird. The best description I have ever seen of the robin redbreast's character is that given by a naturalist, whose fame rests upon the correctness of his observations as much as upon their extent (W. Macgillivray). He described the robin in four words: "lively, pert, pugnacious, cheerful." Can you say anything better than this?

Its Confidence.—The confiding boldness of the robin towards man is in marked contrast to the distrust of most other birds. And this is another important element making the bird attractive to us. We all love to be trusted, and it is more than pleasing when we are trusted by birds or beasts. The robin every winter puts his confidence in man and we like him for it. Can you relate any incident of confiding boldness in the robin which you have witnessed? I met a digger in the soil this autumn who told me the robins not only came quite near him at his task, but perched upon the blade of his shovel as he rested in the midst of his toil.

Once on a wintry day I visited a country school and taught a class of boys and girls. As we stood around the blackboard a robin entered through an open window. That was not an uncommon incident in the school, but soon the bird came, and perching upon the top of the blackboard, unheeding the group of scholars close around, sat there throughout the lesson looking exceedingly pert.

When food is plentiful we see less of the robin. He frequents woods largely, but feeds upon the ground, taking a mixed diet of insects, worms, fruit, seeds, and such like. Where plantations are increasing so also are the numbers of the robin redbreasts.

Combats.—Although we have robins with us all the year, in the autumn many go southward. That is, although they are called resident birds, they mostly all migrate from place to place, seeking warmer quarters and a more plentiful supply of food. One of the incidents in the life of redbreasts is their quarrel with their parents, who force them to leave the old home and seek new quarters elsewhere before winter comes on. These combats are often violent and are partly the cause of these birds being described as pugnacious. But they are meddlesome with other birds also. Have you ever witnessed any of those family fights?

Migrations.—When the weather is very severe the old birds also may be forced to move in search of milder quarters. They may even cross the Channel. On the Continent they generally travel much farther than they do with us, and do not always fare so well, for there they are often killed and eaten.

Nest and Eggs.—The robin builds a bulky nest in hedge, bush, or bank, sometimes amongst herbage on the ground, lined with hair or wool. The eggs—five or six—are very pale reddish, with fine minute reddish dots. The most interesting peculiarity about the nesting habits of the robin is its fairly common practice of selecting unusual objects in which to rear its brood. Although many other birds occasionally build in "freak" situations, the robin is perhaps the most original performer in this way. Letter boxes, tin cans, and even a disused rat-trap are some of the quaint places in which robins have been known to nest. The young robins at first are not like their parents, but are spotted until their first autumn moult. Then they resemble the parents except that the breast is paler. Watch the robins during the winter and learn all you can of their ways. Can you name any other common small British perching birds with ruddy breast? There are several.

Make a sketch of a robin (from memory if you can) noting carefully its shape, the shape of its bill, its large eye, and slender feet. Try to represent it in a robin-like attitude.

Feeding Birds in Winter.—You should feed the birds out of doors in stormy weather. This will give you a good opportunity of recognising different kinds. If you watch their behaviour around the food you will learn something about their dispositions—bold, quarrelsome, timid, greedy, and so on. Try to observe details of structure such as the shape of bill, distribution of colour, shape of body, and so on. Distinguish amongst the birds which crowd to the platter those which are resident birds and the few which are winter visitors. You are not likely to see many of these, but you may be fortunate in seeing the redwing or the fieldfare.

LESSON LXXV.

THE FORM OF FISHES.

[For such an exercise as this, specimen fishes should be obtained as opportunity offers. The whole series, of course, need not be dealt with at one time. One live fish, *e.g.* goldfish, is necessary for the first lesson. The object of the lesson is in the first instance to acquaint the pupils with the relation which exists between the shape of the fish and the medium in which it lives, and secondly to give easy practice in training the eye to note small differences which are of real significance. The teacher will probably be able to plan similar exercises with plants and animals. Birds make quite as effective studies of this kind as fishes.]

Observations on Living Fish.—We shall begin our study by watching the live goldfish. As they move, sometimes slowly, sometimes with sudden active darts sailing along with easy grace, we become aware that they progress through the water with very little signs of effort. There are various "adaptations" in the body of a fish which enable it to move in this easy way. A very important one is its **shape.** After you have watched the fish for a little and noted the ease with which it glides along, turns, rises and sinks, we shall look at its form with some care.

Drawings.—Look at the fish from above and make an outline drawing of it. What shape is this? It is of the spindle or torpedo type. An even rounded surface tapering gently to both ends. Such a shape involves the least amount of friction in passing through the water. It is approached in the shape of a bird as it flies in the air.

If you examine your drawing closely you will see that the shape of the fish resembles two wedges pointing opposite ways—a small one pointing forward, and a long tapering one directed backward. Notice what is the effect of the pressure of the water upon such a shape. It tends, on the whole, to make the body slide forward when the fish makes but a slight effort. The result of the inward pressure upon the long wedge is to produce forward slipping, that upon the small one is to drive the body backward though not nearly to the same extent. This is also more than counterbalanced by the cutting edge given to the body when pressed forward from behind (Fig. 187). Compare A and B in the diagram which explains this.

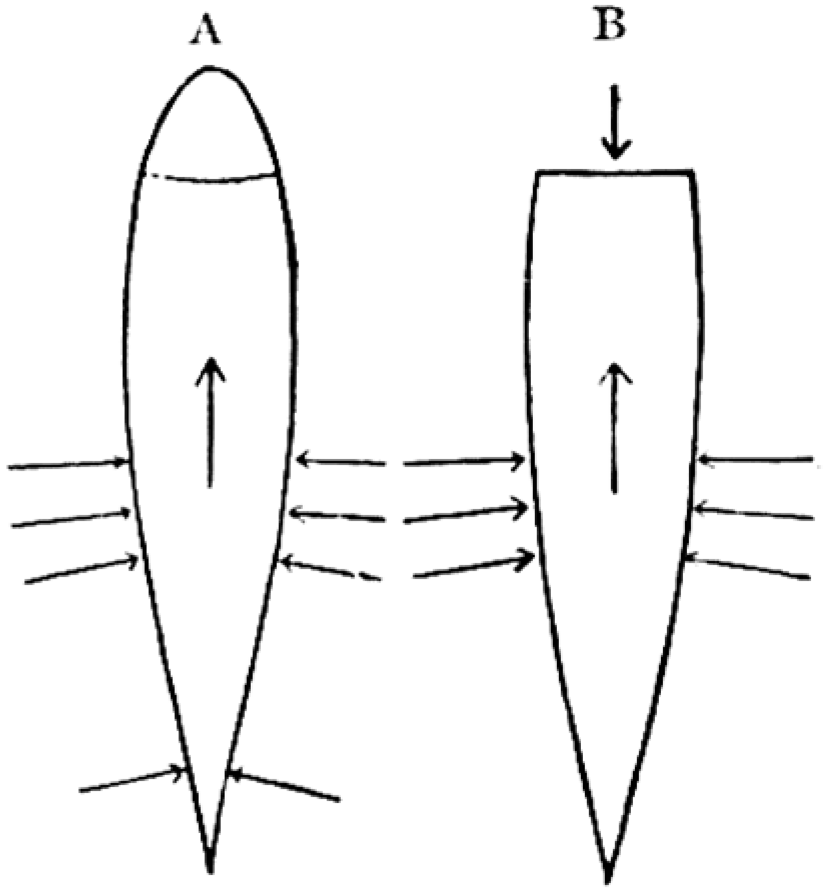

Fig. 187.—Diagram to show the effect of the pressure of the water upon the body of a typical fish. The median vertical arrows indicate the direction of the resultant pressure. See text for full explanation.

Another thing about the form of the fish is the absence of any break or projections from the surface likely to hinder the movement through the water. The side fins which are used in balancing, turning, and other movements usually present a sloping surface or edge, and so are no hindrance. The other fins cut the water with their edges. Watch the living fish, observing how the various fins move in the water, and notice in particular how the side and tail fins present a "cutting" edge, not a flat side, as they make their respective strokes.

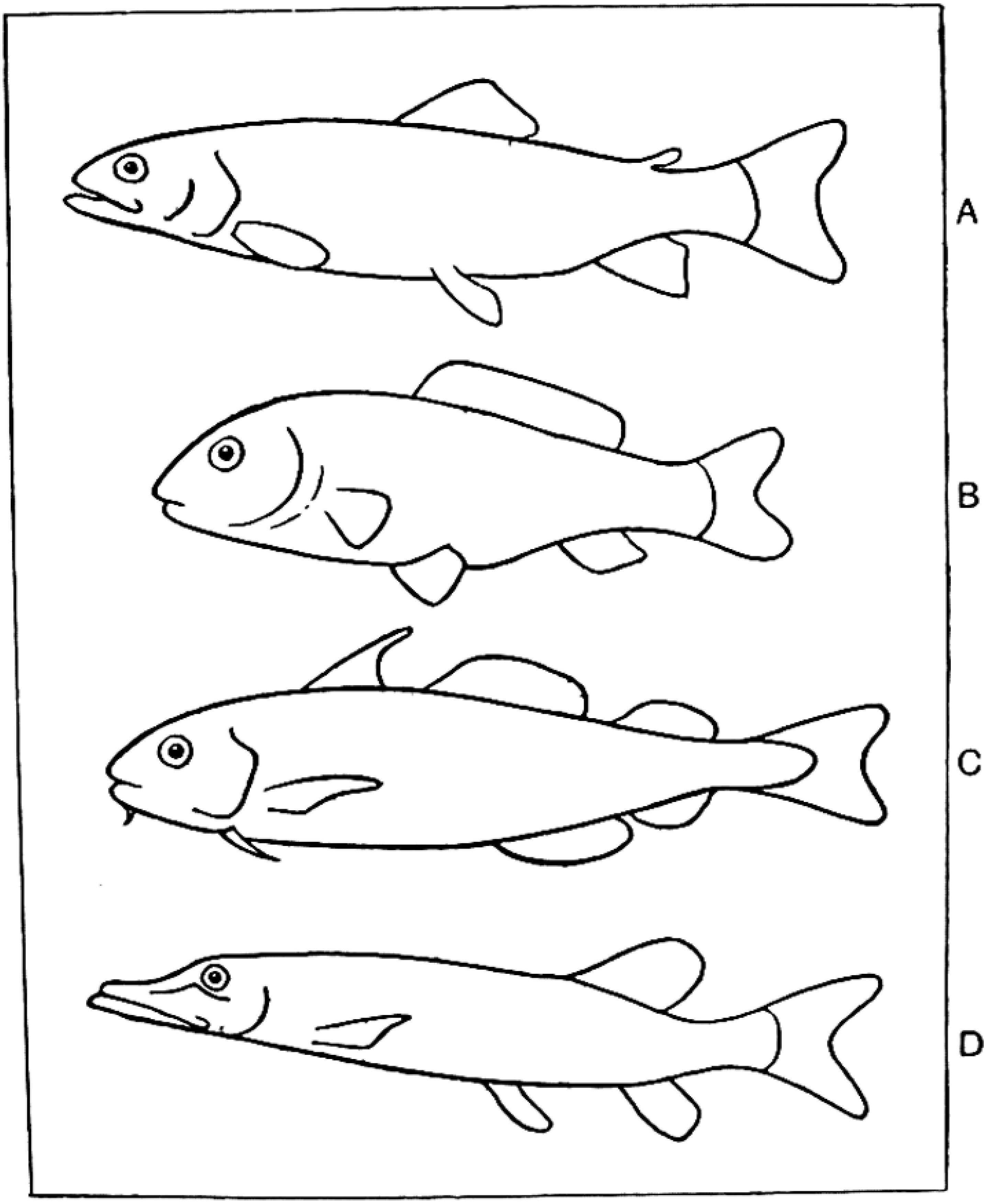

Fig. 188.—Fish Forms. A, Salmon or Trout; B, Carp or Goldfish; C, Haddock; D, Pike.

While the shape of fishes in general is very similar, there are many interesting differences in detail. Here is an exercise of a simple nature which you should perform with regard to as many fishes as you can.

Practise drawing in outline some common fish, such as a goldfish, until you remember the various external parts and can fill them in in their proper place. For example, an outline drawing of a **goldfish,** side view, will show—

(1) **contour line** of the body showing mouth;
(2) **eye and nostril** in correct position;
(3) **gill cover** margin;
(4) **dorsal** or back fin in outline;
(5) **ventral** or underside fin in outline;
(6) **tail** fin in outline;
(7) **front paired fin** (pectoral) of one side (higher on body);
(8) **hind paired fin** (pelvic) of one side (lower on body) (Fig. 188 B).

Learn the names as here given of these parts.

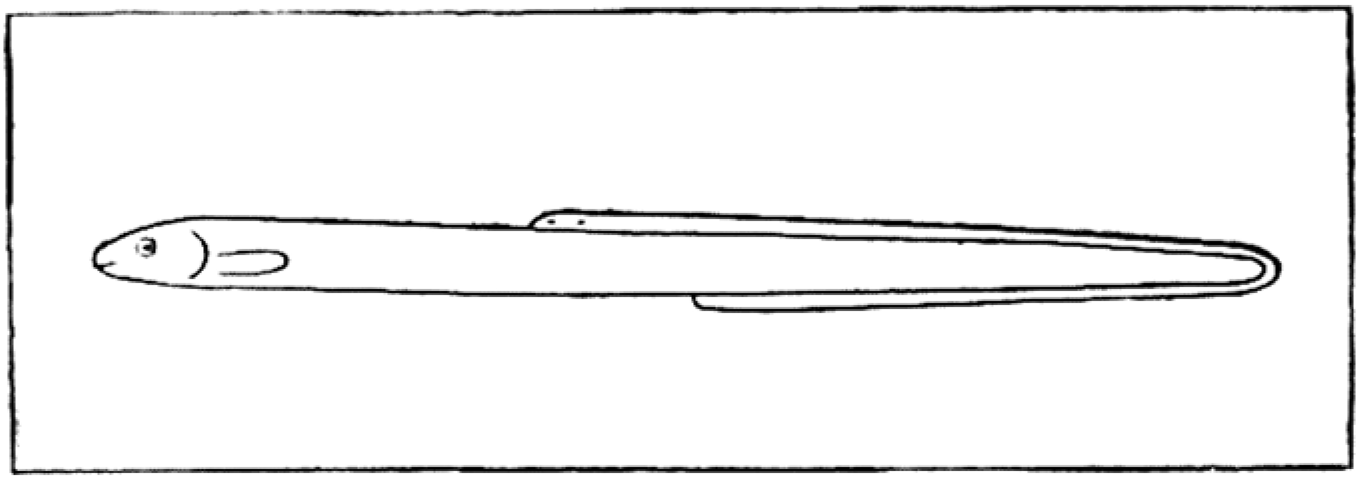

Fig. 189.—The form of the Eel in outline.

Take now another fish—any one of typical shape will do at this stage. Suppose, *e.g.* we take a **haddock,** and perform the same exercise. What do you find in the way of differences?

(*a*) The shape is not quite the same—it is differently proportioned.
(*b*) There are three dorsal fins in place of one.
(*c*) There are two ventral fins in place of one.

(*d*) The hind paired fins (lower on body) are actually nearer the head than the front paired fins (higher on body) (Fig. 188 C).

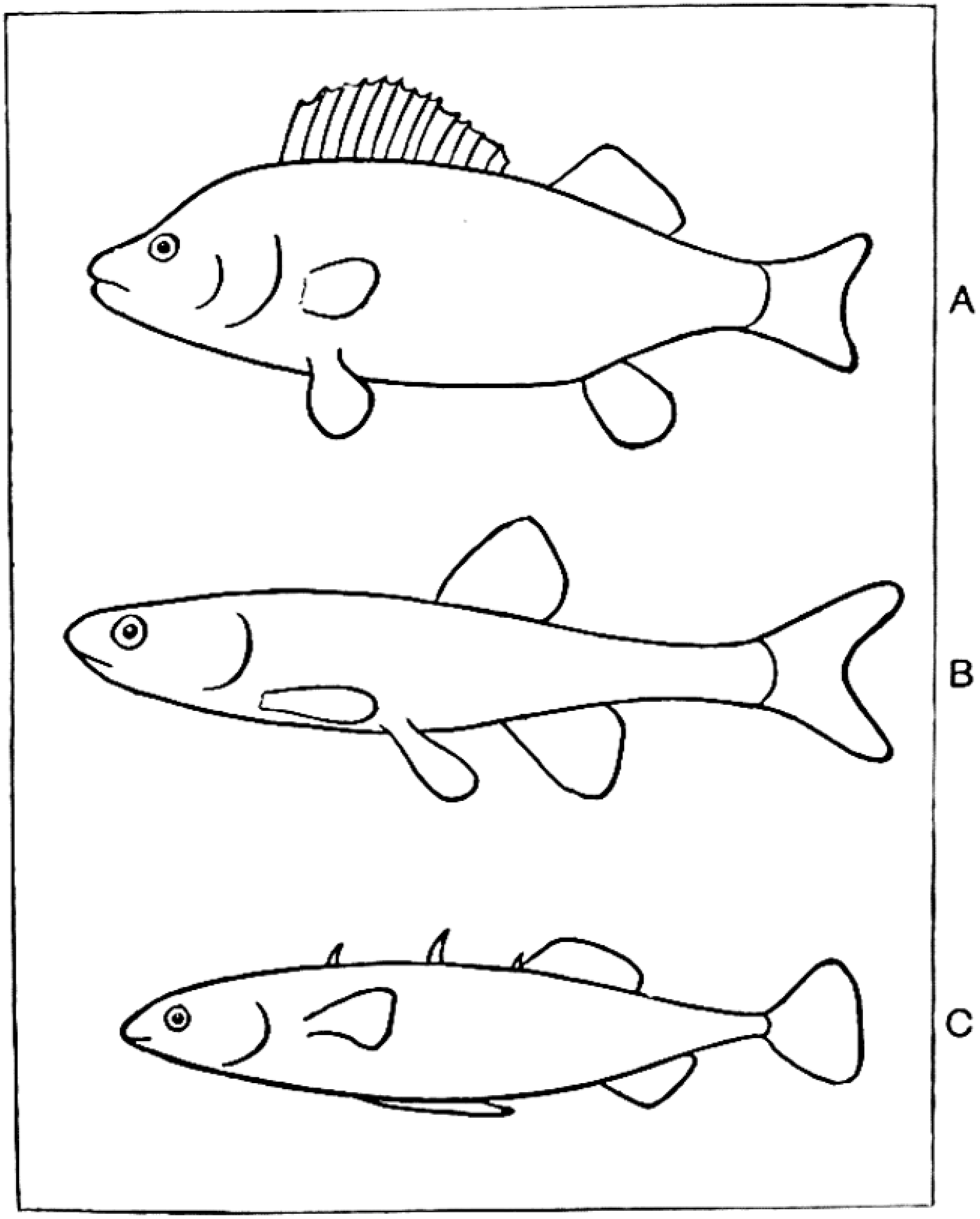

Fig. 190.—A, Perch; B, Minnow; C, Threespined Stickleback.

A trout may next be drawn in the same way (Fig. 188 A).

(*a*) Again the proportions of body as a whole are different.

(b) There are two dorsal fins. (Note the second one has no bony rays and its outline is *rounded*—adipose fin.)

Make a set of such drawings, including as many common fishes as you can. Remember the drawing is not good enough until the fish can be recognised from it.

Some fishes whose form is readily recognisable when drawn in this way, besides those given above, are perch, minnow, pike, stickleback, loach, dogfish (Figs. 189, 190).

The shape of fishes of specialised habit is a subject of interest and is not too difficult for pupils to understand if specimens can be provided. For example, if the pupils are asked to draw a flatfish, *e.g.* flounder, they will discover by observation of the position of the paired fins, gill covers, and other external features that the body of this fish is flattened by the increase, from the average form, of its vertical depth—from back to belly—and that it lies upon its side (the left)—that owing to this habit the head is twisted so that the eye of the lower (left) side is brought round to the upper (right).

The exercise of drawing the skate and naming its parts—a fish of similar habits—will reveal the fact that its flatness is arrived at in quite a different way, viz. by extension of the true sides, right and left—actually by the great enlargement of the pectoral fins.

An interesting case is that of a slow swimming fish, accustomed to poising itself in the water whilst "stalking" its prey, the John Dory, which is flattened in a vertical direction, really in the same direction as the flounder, but it does not adopt the lying down habit, and its eyes are upon opposite sides of its head.

For a Study of the Structure of Fishes in relation to movement in water see *Aims and Methods of Nature Study*, p. 67.

LESSON LXXVI.

THE PUPA OF THE CABBAGE BUTTERFLY.

[This pupa is selected for study because it is one of the commonest and most easily found. Search should be made in crevices in garden walls where vegetables are grown, under eaves of outhouses, on palings and similar places. It is further suitable for study because it exhibits a fair amount of structural detail not seen on pupae generally.

Such pupae may of course be obtained by the rearing of caterpillars collected in autumn.]

Suggested Observations.—Most of you have likely seen this object and know what it is. Yes, it is the **chrysalis or pupa** of a butterfly. How do you know that? There are two excellent ways in which you may gain such knowledge, and if you have not proved the truth of your answer in either of these ways you should do so. One way is to collect the caterpillars of this butterfly at a suitable time (p. 234) and feed them until they become transformed into pupae. The other way is to keep the live pupae until they hatch out and watch the process for yourself.

Meaning of Terms.—Before we go further let us notice the meaning of these two names. We sometimes speak of a chrysalis and at other times of a **pupa.** Pupa is a common name for this stage in many kinds of insects. The word really means a "doll," and you can see of course why it is used here—it is a little image of the butterfly that is to be. The word chrysalis really means "golden." It is not used for any kind of pupae except those of butterflies, and it applied originally to such pupae of butterflies as have a surface which gleams with the lustre of metals. Have you ever seen such pupae? Those of the small **tortoise-shell** butterfly frequently show this appearance, the **red admiral** has a golden gleam along the back as well as upon the projections of the body, and various **fritillaries** also exhibit the characters of true chrysalids.

Naming of the Parts of the Pupa.—Now you must draw the chrysalis. As you do so notice the following: Distinguish the front and hinder ends of the body. That is easy. Notice next the ridges and angles upon the surface. Can you say where the more prominent of these are placed?

At the front the chrysalis projects in a single point; at the hinder end the tip is broader and is really double. From the tip in front there runs a ridge along the middle of the under surface to the hinder end. Is it an even ridge? No, at the fore end it is raised into one prominent point, and into smaller ones more or less distinct along the body. There is also a pair of ridges along the sides, continuous and very distinct in the hinder region, less so in front.

You recall that there are three divisions in the insect body—head, thorax or trunk, abdomen or hind body. How much of this can you recognise here?

The hind body is very distinct. It is jointed, and you can see the divisions clearly, especially along the under side. Follow these with the help of a lens. As you pass your eye along the sides, do you see just above the lateral ridges small oval areas each with a slit in the middle? These are very distinct at the front end of the abdomen. Represent these carefully in your drawing.

Where have you seen such openings? On the sides of caterpillars. What are they? They are the **spiracles** (stigmata) or openings through which insects breathe. Does the chrysalis then breathe? Yes, for it is alive.

Passing forward along the side of the body you next observe on each side a large triangular area. The longest side of this triangle lies along the back and is slightly curved. The lowest part of this triangle runs down to a sharp prominence upon the hind body immediately below, and the fore part is well to the front and may be said to end in a rounded thickening which you will find there. Go over all this yourselves and fill in this region correctly in your sketch. What are these areas? They mark the outline of the **wings**, which lie immediately below.

The wings do not meet above. Look along the upper side of the chrysalis. What do you see running above them and lying between them at their hinder ends? Two slender rows of black and yellowish dots. They curve back from in front of the wings, passing over these in their upper region at the front and lying between them behind. Can you think what these rows represent? These are the feelers or **antennae** of the future butterfly. Do you recall the shape of a butterfly's antenna? It is thickened at the tip. Can you recognise the thickening here? Yes, we can see this interesting feature with great clearness.

Below the front corner of the wings there is a marked prominence upon the under side. This represents the middle division of the trunk, to which the fore wings are attached.

Trace the antennae forward. They arise just below the tip at the front. Quite near their origin, but a little way behind and above them, there is a glistening crescent-shaped mark on each side. Do you see these? What are they? These are the **compound eyes** of the butterfly. Show them correctly in the sketch which you are making.

You notice then how much can be discovered by close looking.

Have you seen any indication that the chrysalis is living? Yes, when handled it frequently jerks its hind body to the side. This is the only part which is freely movable.

The chrysalis stage, as you know, is one of slow change. Inside the outer shell there is a breaking up of caterpillar organs and a building up of new ones suited to the different life of a butterfly. You can get chrysalids of the cabbage butterfly in summer also. Do they last as long as the winter ones? No. The summer chrysalis period is much shorter. The winter one is longer, because then there is no food for butterflies and it is a safe and easy condition in which to pass this perilous time.

Endeavour to find some other winter pupae out of doors and compare these with the Cabbage Butterfly pupa. There are not many which you will find that show so much of the structure of the coming insect as this one does.

LESSON LXXVII.

INSECT STRUCTURE AND CLASSIFICATION.

(*A Revisal Study.*)

[For the purpose of this lesson, the teacher should have suitably pinned out or mounted insects to represent the six Orders dealt with in the lesson. He should be prepared to make drawings of these, or to exhibit good diagrams. The work should be distributed over as many lessons as is considered necessary.]

I. In the course of the year we have become familiar with a number of different kinds of insects, we have seen different stages in their life-histories, and we have from time to time taken notice of particular parts of their bodies and the uses of them, we have learned a little of their habits and the places they frequent, of the harm they do in some cases, and of some which do good. We shall now in this lesson try to gather together and put in order the more important of the facts which we have learned.

Insect Characters.—First of all it will be useful if we make clear the marks by which an insect may be known from other creatures. For we no longer use the name except for the kind of animal it really represents. Here is a common insect (cockroach, beetle, etc., any typical example will do). Will you look at it so as to see the things I speak of, and write these down in the form of a list. You must also make a diagram in your note-books, and name the parts shown upon it.

First of all look at the surface of the body. It is covered by a tough, but more or less yielding, skin (**cuticle**). This substance differs in colour in different kinds of insects. Very often it is brown, as in cockroaches; it may be black, as in many beetles. It may be of more than one colour, as in the bands of black and gold upon a wasp, or in the brilliant hues of butterflies. It is often transparent, especially in the wings of flies or bees. This tough outer covering is a characteristic of insects. They are not the only animals which possess it, but no insect is without it. The substance is called **chitin.** It not only serves as a protection to the body, but being strong also serves to support and keep in place the organs within. To it are fixed the muscles which move the legs, wings, and other parts of the body. Write out, therefore—

(1) *All insects have a protecting and supporting covering to their bodies, which consists of* CHITIN.

Look next at the hind portion of the body. Do you see that it is crossed by lines or grooves? Yes. We can always see these cross-lines in an insect. The whole body is really made up of a series of divisions or **segments,** as they are termed. These are not so clearly recognisable in the fore part of the body in some insects as in the hind part, but they are really there. I am sure you know other animals which have a body made up of segments or rings. There are the centipedes for example, and also worms. Again, however, although other creatures show segments as well, no insect is without them. So well is this recognised that the name Insect refers to this. It means "cut into" or divided. Write down—

(2) *All insects have a body divided transversely into a series of segments or parts.*

These joints or parts of an insect's body are arranged into three groups. We can very readily recognise these. Look at the insect and notice the following:—

(*a*) The **head.** It carries the jaws and mouth below, the eyes and one pair of feelers above. A neck constriction usually separates the head in adult insects from

(*b*) The **thorax** or middle body. It really is composed of three parts. On the under side of the middle body are the legs, and in winged insects the wings arise from the upper side.

(*c*) The **abdomen** or hind body. This never has legs, but at the tip or near it there may be outgrowths, such as the little filaments upon a cockroach, the long thread-like tails of mayflies, or the sting of a bee.

This *clear* grouping of the body divisions into three is quite peculiar to insects.

Write down—

(3) *The insect body consists of three main divisions, viz. head, middle body* (*thorax*), *and hind body* (*abdomen*).

Look next at the insect's legs. How many pairs are there? Three pairs. Are they all in one piece? No. The leg is jointed, and there are a good many pieces in it. Write down—

(4) *The limbs of insects are three pairs of jointed limbs.*

These **four things taken together** will serve to distinguish an insect from any other kind of creature. These are all things which you can recognise upon the outside. Besides these there are, of course, important internal parts peculiar to insects, but it is not necessary for us to deal with them. You may notice also that most insects have wings, but there are wingless forms also.

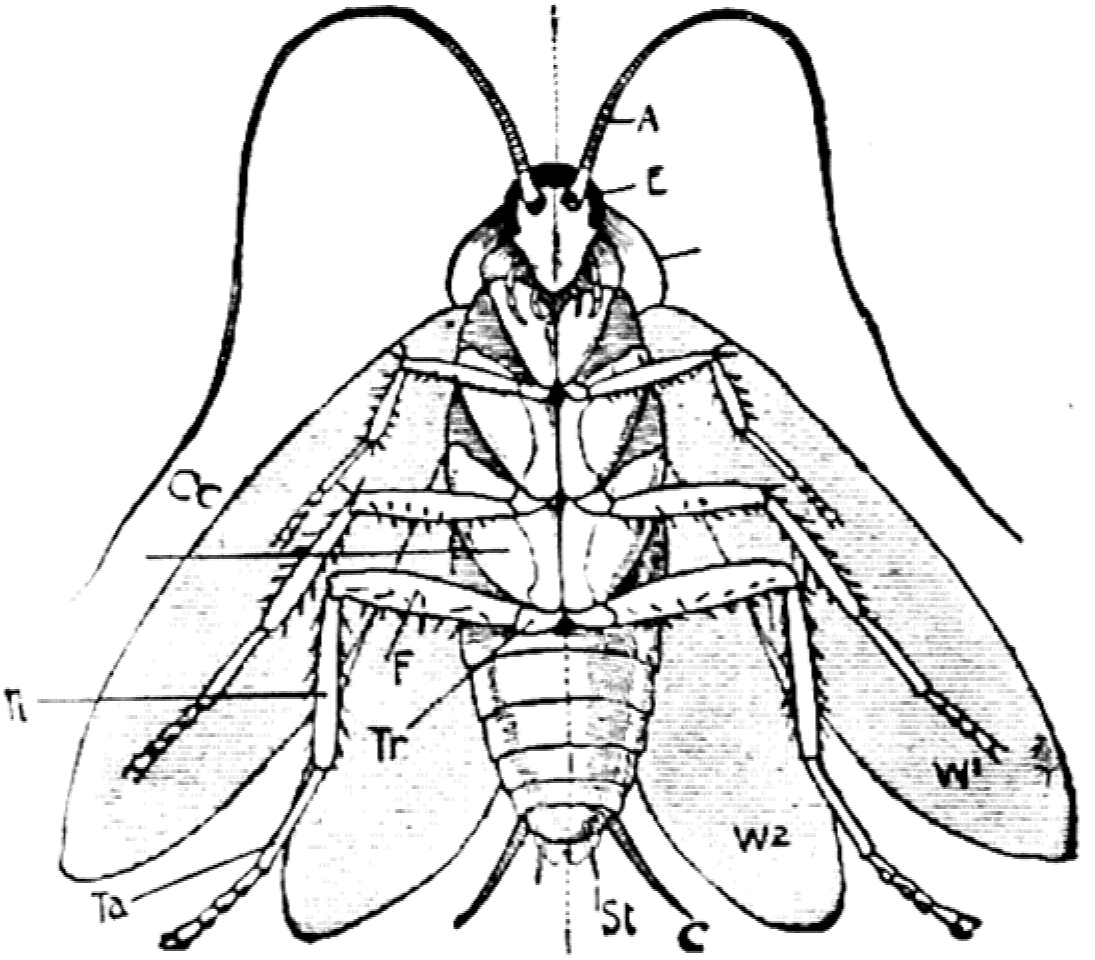

Fig. 191.—Diagram of Insect Structure. Note the head with its antennae, compound eyes and mouth parts; the thorax with its three pairs of legs and two pairs of wings; the jointed nature of the legs; and the segmented hind body.

Now you must make a diagram of the parts of an insect, and name these clearly (Fig. 191).

Modifications of Form and Colour.—All this deals only with the general appearance. But there is an almost endless variety of form and colour, the special meaning of which we can often see very clearly in certain cases. Sometimes the insect resembles greatly an object upon which it is accustomed to rest, the result of which is that the insect is very well concealed and thus protected. Many caterpillars, for example, resemble the twigs of the bushes on which they feed, or resemble their foliage. Many moths, *e.g.* the crimson underwing, resemble the bark of trees upon which they habitually rest. This is called **protective resemblance.** It is not uncommon, and you should keep a look out for examples of it.

Sometimes one insect resembles another of a different kind very closely. For example, there are various flies which are so like bees or wasps that they are constantly being mistaken for them (**hover-flies**). When one insect resembles another in this way, it is usually the case that one is harmless and the other is provided with some weapon. This kind of resemblance is called **mimicry**—the harmless form is the mimic, and it derives protection from the resemblance. Do you see in what way?

II. Now we must distinguish the commoner kinds of insects. Here are six different types: **butterflies** and **moths, bees, flies, beetles, cockroaches, green-flies.** These forms all differ in the wings as well as in other particulars. Let us look at them in turn.

Butterflies and moths are usually easily distinguished from other insects. Their two pairs of wings bear very small **scales,** which are arranged so as to form definite patterns. The beautiful colours of these insects are due to the scales; they usually cover the whole wing, but in the clear wing moths there are parts without scales. The fine dust which comes off the wings of these insects when they are roughly handled consists of scales. Can you name twelve common butterflies you know at sight?

Butterflies and moths feed on liquid food, which they suck by means of a long proboscis. Have you looked at this organ? (Figs. 100, 101.)

The young form is always a **caterpillar.** What is a caterpillar? (p. 228) (Fig. 194). *Order: Lepidoptera.*

In bees the two pairs of wings have no scales; they are thin and transparent, resembling those of flies. Their young form is termed a **grub.** It is very helpless as compared with a caterpillar. It has a head, but its feet are absent. It is a degraded grub. *Order: Hymenoptera.*

In **flies** the wings consist of one pair only. These are thin and transparent. The young of flies is a maggot. A **maggot** has no feet at all, and its head is very imperfect or absent altogether. You should be able to name at least six common flies you know at sight. (Examples: house-fly, blue-bottle, green-bottle, daddy-long-legs, gnat, currant hover-fly.) (Fig. 192.) *Order: Diptera.*

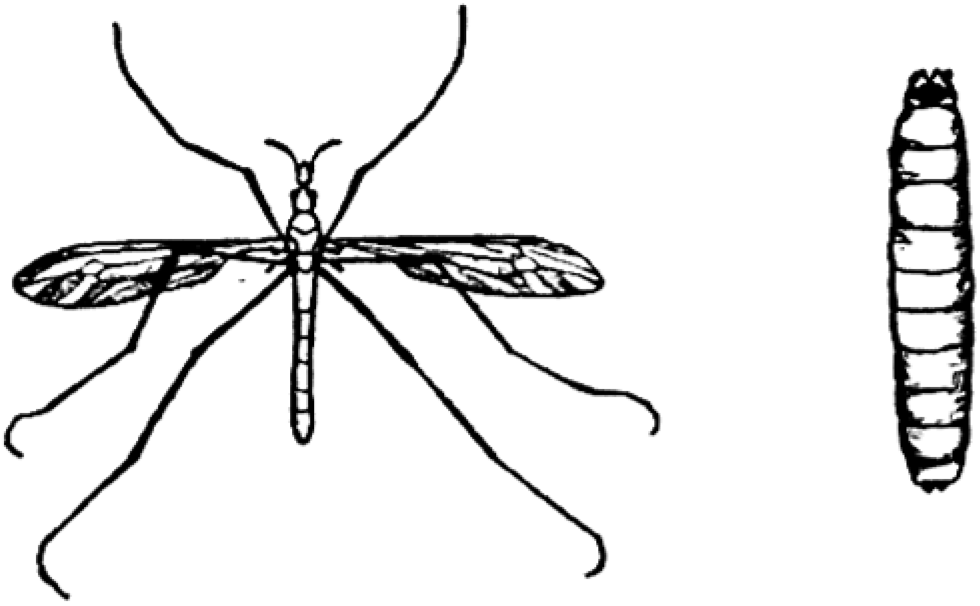

Fig. 192.—Crane Fly (*Tipula*) and larva ("leather-jacket"), slightly less than natural size.

Beetles.—What are the marks of a **beetle?** In a beetle the first pair of wings is much harder than the other pair, and is not used for flying. It serves as **covers** (elytra) for the true flying wings. Usually these covers hide the whole of the hind body as well as the true wings. In a few they cover only a part. Such beetles have a habit of turning up the tip of the body over the back, and thus have got the name of "cock-tails." The well-known beetle called the "devil's coach-horse" is a cock-tail beetle. The young of beetles are **grubs,** with three pairs of fairly strong feet. Name some common beetles (Figs. 193, 194). *Order: Coleoptera.*

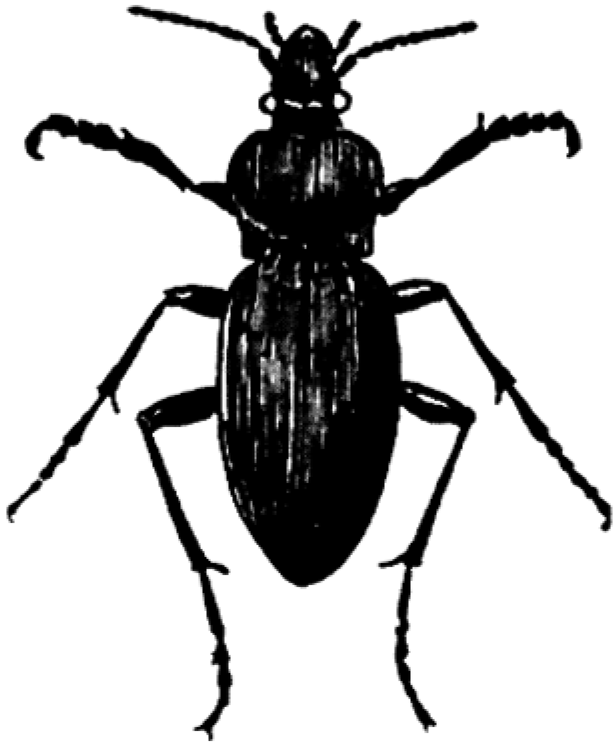

Fig. 193.—A Ground Beetle (*Carabus*).

Grasshoppers, etc.—Many people think the **cockroach** is a beetle. But if you look at one you can see that cockroaches have no wing covers. They have two pairs of

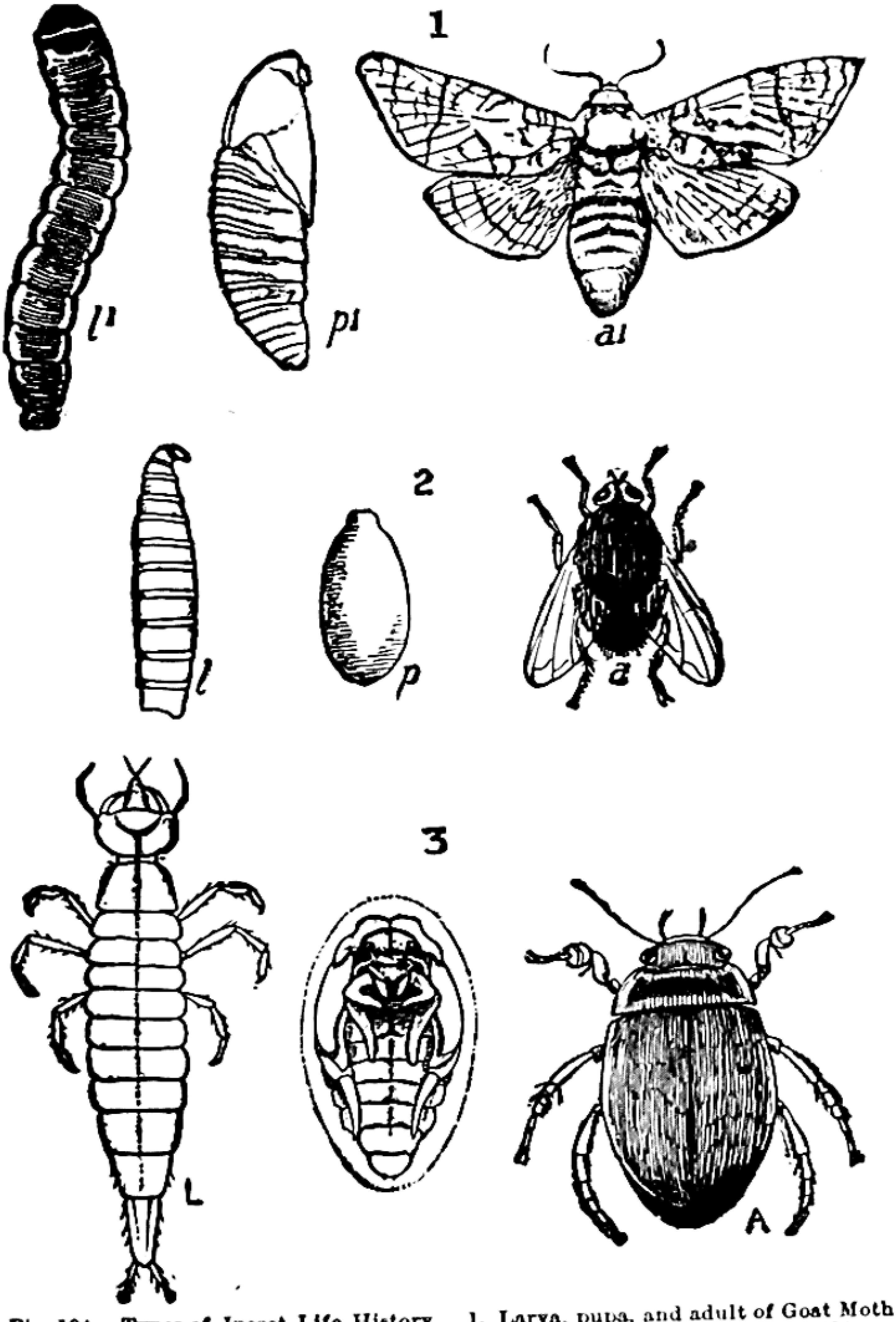

Fig. 194.—Types of Insect Life History. 1. Larva, pupa, and adult of Goat Moth (*Cossus ligniperda*). 2. Larva, pupa, and adult of Bluebottle Fly (*Musca vomitoria*). 3. Larva, pupa, and adult of Water Beetle (*Dytiscus marginalis*). These last show adaptations to aquatic life.

wings upon which there are **very** many lines or veins as they are termed. These **veins** are very **straight,** and do not branch at all, or very little. This group is called the group of straight-winged insects (*Orthoptera*). The young forms belonging to this group are just **like their parents,** only they are without wings. Grasshoppers, crickets, locusts, and the insects known as "stick" insects all belong to the cockroach group.

Bugs.—The **green-fly** are peculiar in that only certain generations have wings. They are better distinguished by a sharp **needle-like rod** which they have in front of the mouth, and which they use for sucking the sap out of plants. They belong to the order of **bugs,** which all have this kind of mouth. The young of green-fly, too, are very similar to the adults, only they never have wings. Some of the insects you have become familiar with in ponds or in your school aquarium belong to this group. These are the **pond skaters,** the **water boatman,** the **water scorpion,** and the **corixa.** *Order: Hemiptera.*

Besides these few there are many other groups of insects. But if you have learned to recognise these six kinds and know the commonest examples of each kind, you have made a very good beginning with the study of insects. You might sum up this lesson in picture by drawing one of each of these six groups.

See also "Suggestions for the Study of Insects," *Aims and Methods of Nature Study*, Chapter XII.

LESSON LXXVIII.

THE SHORE CRAB (*Carcinas maenas*).

[Crabs are "common objects" of the seashore, and may be got without difficulty. If several different kinds can be obtained they will be of value to illustrate particular points. In schools near the seashore, where salt water can be obtained, live crabs should be used. Teachers inland who take the trouble to obtain a specimen for lesson purposes will find themselves repaid in the interest aroused amongst the pupils.]

Some Questions to Ask.—Crabs are amongst the first of the shore animals to attract our attention, and there are many things about them which it will interest us to inquire into. You have often looked at them in the pools upon the seashore or clambering upon the rocks. Have you ever asked any questions about them? For example, have you ever wondered at their shape, or why they have so many legs, why they have hard shells to their bodies, why they have such strong "pincers," why they are so quarrelsome, so ready to defend themselves, what they eat, where their mouth is, how they can live out of water? If you have not thought of these things before I hope you will want to hear the answer to some of the questions now.

The Form of the Crab.—Crabs have a rather strange shape. The head and body are closely joined together, the back is very broad, and the tail is very thin and flat and turned in beneath, pressed into a groove on the under side of the body. The legs are long for the size of the animal, and give it a "sprawling" appearance. You must take a good look at the crab so as to see these things. Draw a crab and you will become more familiar with its puzzling features. I think that if you do so, before your lesson is over you will see the meaning of some at least of the things which give the crab its queer appearance.

Let us try to think of the place where crabs live. In the pools amongst the rocks there are a great many animals of different kinds, and a good deal of hunting and being hunted goes on. **Hard shells** and **biting claws** are simply **weapons** for use in this animal warfare. The shell is the crab's defence against the attack of the teeth of fish, and the claws it uses against all meddlers, as small boys mostly know. And it is not always the big creatures which attack crabs. One may see in a shore pool a crab hard put to, and have to struggle very hard to pull itself out of the grasp of the tentacles of a sea anemone.

Its Claws.—It is worth while looking for a moment at a crab's claw. Its powerfulness everyone knows who has ever felt its grip. Yet it is a very simple device. If you look at the limbs you will see that they are all jointed. Examining the great claw you notice that this consists of a rigid part, against which a movable part works. This movable part is just the last division of this limb. The rigid part you notice is simply a drawn-out portion of the next, or second last, division. The end division is provided with a flat tendon and muscles, and when these pull it is pressed against this prolonged portion, and we say the crab "nips" or bites. Children often amuse themselves pulling the tendon in a broken claw.

You must make a drawing of a crab's claw from the object itself.

Regrowth of Lost Limbs.—Sometimes crabs lose a limb in the fights and struggles which are constantly going on at the shore. This is so frequent an occurrence that they are provided with the power to grow again a limb thus lost. If you should find a crab with one limb very much smaller than the others you will now understand that this is one in the process of regrowth.

These are just one or two of the things which show us how much struggle goes on amongst animals—especially on the seashore. Some others showing the same things we shall have to speak about later on.

Why a Crab has a Broad Back.—Now let us look at the crab once more, and this time we shall try to understand its shape. The shore crab is rather angular; that is, it has more or less well marked corners. The edible crab is more rounded, giving a roughly oval outline. Of course there are many different kinds of crabs, and the shape is more or less different in each, but the most familiar shape to us is that of the common shore crab. It is roughly five-sided, the two front margins being notched.

Do you know how crabs breathe? They have gills which grow out in a large cluster on each side of the body. But you will ask, of course, where are they? You do not see them. If you could lift off the shield which covers the head and back, and which folds round to the under side, lying close to the legs you would find the gills. This shield at the two sides spreads outward away from the sides proper of the body, and bending down below encloses on each side a large space. This space is known as the breathing chamber, and in it the gills lie. When the crab is in the sea it is constantly pumping water through this chamber by means of a tough leaf-like flap situated near the mouth. This flow of water brings oxygen to the gills.

Breathing.—Now you know that crabs are often out of water. We find them at low tide clambering upon the rocks or wandering on the shore. How do they breathe then? You will notice that the openings into this breathing chamber are very narrow. The shield fits quite close to the legs on the under side, so that the chamber within may be said to be very close, although it is roomy. It is also very damp, because the gills and all the other parts are wet, and, unless the crab is out of water for a very long time in a dry place and under a hot sun, though stranded, it can still breathe the moist air in its chamber until the tide returns and it gets covered over.

You see now that the crab has a **broad back** so that it may have a **large breathing space.**

Its Senses.—What are these short thread-like parts in front of a crab's head? These are commonly called feelers or antennae. There are two pairs. They are very useful to the crab, for with them it tests or touches things, it smells them, and in the smaller pair it has also an organ which helps it to balance itself or walk straight.

Do you see the crab's eyes? What is peculiar about them? They lie in a groove, which shelters them from injury when crabs fight. But they are set on short stalks and the crab can raise these up, so that it can not only look out in front but also look over its back if it care to.

Mouth and Jaws.—Where is the crab's mouth? Do you see a pair of flat-jointed plates, like two folding doors, in the middle of the under side in front of all the legs. Between these, lying deeply, is the mouth, with a pair of strong biting jaws in front of it. The "folding doors," along with the jaws, tear and break up the food before it enters the mouth. It is further broken up in a large gizzard which lies within.

Tail.—Do you know the crab's purse? This is the jointed flap which folds under the body from the hinder end. It is really the crab's "tail" or hind body. When the crab is quite young this tail sticks out behind like a lobster's, but gets curled under later. The lobsters use their tails for swimming with, but ordinary crabs do not swim.

If you examine a number of crabs you will find that some have rather narrow tapering tails, whilst others have broader and more rounded ones. The former are male crabs, and the latter are females. Be sure and always examine the crab's purse when you have an opportunity.

Eggs.—Sometimes you find a crab with a very full and gaping purse. This is a female. Fishermen call these "berried" crabs. If you look closely you will find that there hang on to the hairy appendages on the under side of the tail flap countless very small round berry-like or seed-like bodies. What are these? These are the crab's eggs. And they are carried here until the young are hatched. This is another illustration of the risks of the seashore. If the crab left them in a corner to hatch out they would surely be found by some hungry creature and eaten.

Now you know why a female crab has a broader tail than a male one. It is to give a better protection to the eggs she has to carry.

Other Crabs.—Sometimes in the rock pools you see other crabs besides the common shore one. There are hermit crabs, whose tails are long, but so soft that the creatures dare not crawl about without first covering them up. This crab inserts its tail into the empty spiral shell of some mollusc and drags this about wherever it goes. There is another interesting form which you frequently miss seeing because it hides itself under seaweed and other things which it fastens on to its own back. This is called the masking crab, because it masks or conceals itself so that it may the easier capture its prey. Then there are crabs which live in partnership, some with sponges, others with sea anemones. All these arrangements or devices are meant to make life safer and easier for the crabs. They illustrate clearly how real is the struggle for existence in the crab world.

LESSON LXXIX.

THE STARFISH (*Asterias rubens*).

[Material may be collected in pools by the seashore. Dead examples may be got off fishermen's lines, but unless perfectly fresh and looking well should not be used. The living starfish is best. Some sun-dried and cleaned examples will be found very useful in addition.]

This is an animal which early attracts our attention when we visit the seashore. It is one of the wonders of the rock pool. Young and old often look at the starfish, but few who do so make very much of it. To most people it is a queer, cold, not very attractive thing, not only soulless, but without even a body as far as they can see—all arms or legs, they are never sure which.

But the starfish deserves more notice, as it certainly can arouse more interest. I hope you have been able to procure some and are now looking at them. Be sure to place them in water and to examine them in this way.

The Form of Starfish.—The first thing, I think, which puzzles us about the starfish is its shape. It is quite true that the shapes of animals are very varied, and that the more we get to know them the less surprised we are at out of the way shapes. Still there are many odd forms, and the starfish is one of these.

Now what are the peculiarities of the starfish shape? First it has neither a head nor a tail end. Most animals have these, and with them, of course, right and left sides. But we cannot make these out in a starfish. Animals with heads and tails, and right and left sides, are said to have **bilateral** (that is, two-sided) symmetry. The symmetry of the starfish is of another kind, known as **radial.** We shall see what this means presently.

Position of Mouth.—Then the mouth of the starfish is in the centre of its body. Turn the creature over so that you may see the under side. In the centre you see the opening of the mouth, surrounded by soft white fleshy folds. Do you know any other animal whose mouth is in the middle of its body? Perhaps you know the sea-urchin, which is really very like a starfish, though that is not generally noticed at first; its mouth is in the middle of the under side also. Another common animal with its mouth in this position is the jelly fish. But after all there are not many, and certainly none of the more familiar animals. All animals of circular or starlike shape live in water, and nearly all in salt water; that is part of the reason why they are less well known.

Disc and Rays.—We speak of two principal portions of a starfish body. There are the five tapering parts, known as the rays or arms, and the central part from which these rays point outward. This part we call the disc. The upper side of disc and arms is usually coloured, generally a reddish tint, the under side is pale. On the upper side of the disc and arms are granules and rods of various sizes, but in particular there is always one rounded particle larger than the others, paler than the surrounding parts. It lies towards one side of the disc, opposite the fork between two of the arms. This is a rather important part of the animal, which you may call the "**water plate**" (*madrepore*). It is really full of a great many winding pores, through which water is admitted to certain channels in the body. Without this fluid the starfish could not creep (Fig. 195).

Between the framework of harder particles on the starfish are softer places. In the living animal you can see that in many places these are raised up into little bladder-like bodies, which act like gills, and by their means the starfish breathes.

Have you ever been struck with the cleanness of the starfish's skin? In the sea slow-moving creatures are often settled on by sedentary as well as other animals. Worm tubes, acorn shells and other shells, sea firs, sea squirts, and various other forms settle on stones, sea-weeds, mollusc shells, and such like, and even sometimes on lobsters, but you never find such upon a starfish. How is this? It is because scattered amongst the granules and rods upon the back of the starfish are tiny **snapping pincers** which at once grip any small creature which comes in contact with the skin. Such never get an opportunity of settling upon the back of a starfish. (The pincers are known as *pedicellariae*).

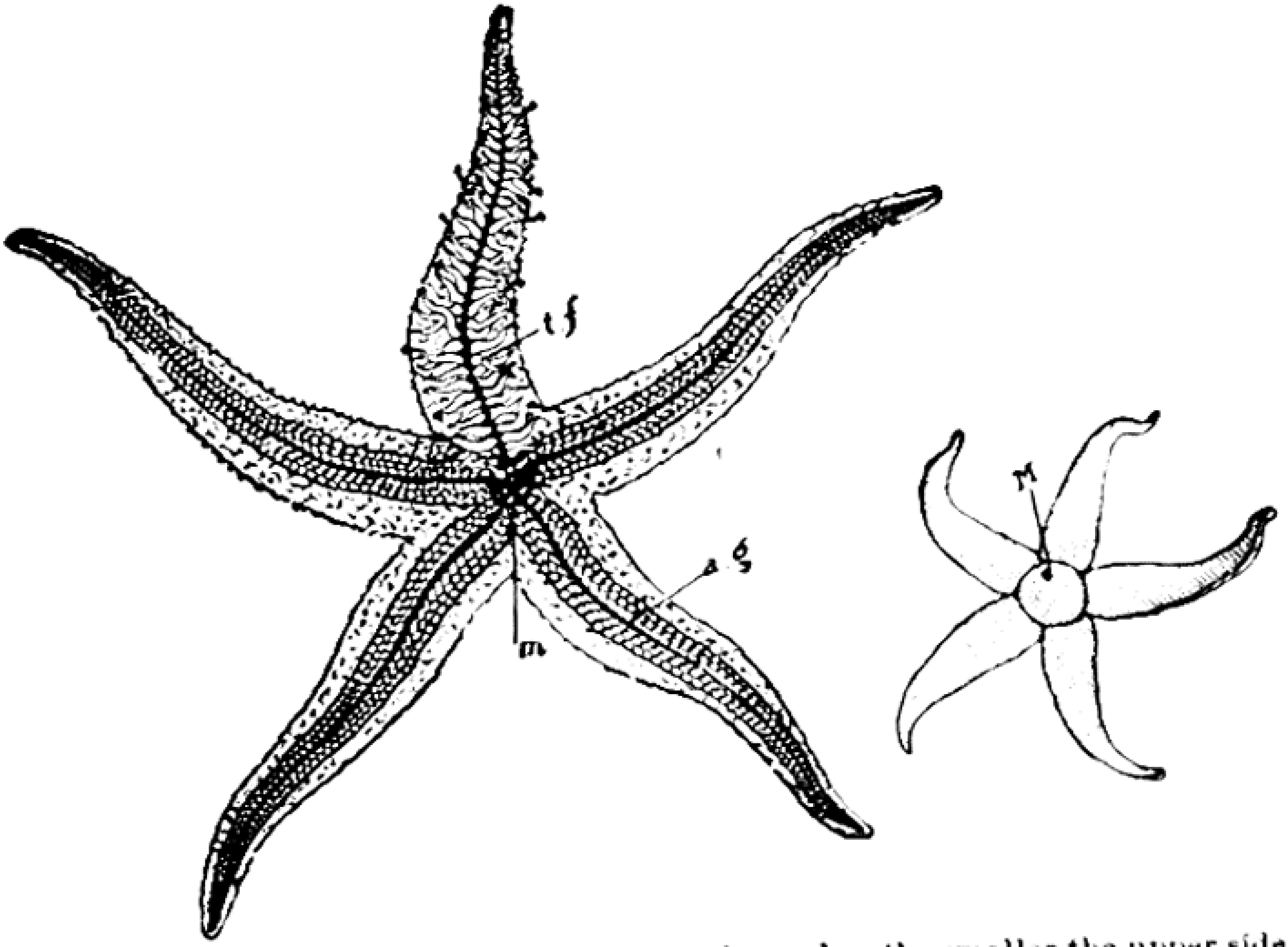

Fig. 105.—**Starfish.** The larger figure shows the under, the smaller the upper side. M, the madrepore, the spot referred to in the text. Other references are *m*, mouth; *t.f.*, feet; *a.g.*, the ambulacral groove on underside of the ray.

Eyes.—Look carefully at the tips of the arms of the starfish. Do you see little reddish dots, rather well protected by little prickly points? Can you say what these are? These are the eyes of the starfish. They may not be very good eyes as far as seeing clearly is concerned, but with them the starfish is able to tell the light side of a pool from the dark, and they may be useful in guiding it as to the shallowness or depth of the water in which it is living.

Feet.—Turn over the starfish and now look at the under side. What are these soft fleshy-like tubes with flat sucker-like tips which wave about as if groping to catch hold of something? These are the creature's feet. Notice the enormous number of them. How are they arranged? If you watch the creature for a little as it gropes about with these you will see that they come out from the ray in two main rows, between which there is a kind of gutter or groove running along the under side from near the mouth outward to the tip. If a starfish is left upon its back in a pool, it is able slowly to turn itself over by means of its feet, using them like suckers upon the rock or stones near by.

How it moves.—The way in which a starfish walks is very wonderful. Every foot is a sucker. These are fixed to the rock and pulled off again just as the starfish needs to, the body being drawn along towards the fixed part. One of the best signs that the starfish has no head end is the fact that it may walk with any side foremost. The best way in which to see the starfish moving is to place a living one in a glass vessel containing sea water. You will then witness the placing and pulling of the sucker feet, and may be fortunate in seeing the starfish climb up the side of the vessel. The movements may not be very fast, but you cannot but notice and admire the orderly way in which all the parts concerned do their work.

Feeding.—Besides creeping about, the sucker feet are used in other ways. They are useful in capturing and in dealing with the food of the starfish. Upon what does it feed? Mussels are a common article of diet, but starfish feed on other animals when they capture them. If you have ever tried to open a mussel shell with the living animal within you know how difficult it is. You cannot do it with the fingers alone. How then can a starfish open a mussel?

When it captures one it seizes it by means of the sucker feet, placing the mussel under the mouth. It then raises up the central disc, drawing its arms together after the fashion of a half-closed umbrella. Fixing the sucker feet nearer the tips of the arms on to the ground to steady itself, and meantime those feet nearer the body on to the two halves of the mussel, it pulls these apart. If it were a short sudden pull the mussel could resist, but the pull is a steady long-continued one which wears the mussel out. As the shell begins to gape, the starfish inserts the edge of its stomach, which by this time has been turned outside the mouth, between the two halves of the shell, and commences to digest the mussel, eventually cleaning out the shell. Should the mussel be a small one, the whole thing is swallowed, the empty shell being afterwards turned out.

Comet-stars.—Do you know what a comet-starfish is? Sometimes you find on the seashore starfish with one or more very short arms and the others long. A true comet-starfish has four quite short arms and one fully grown one. You can easily see why such a form should get such a name. What is the meaning of these short arms? They are the signs of a very remarkable power which starfishes and some few other animals have.

You will readily see that a five-pointed animal has a certain disadvantage in life, especially if it is not a very active animal. There are just five ends at which it may be attacked or laid hold of. A small fish may seize an arm, so may a crab or lobster. An unwary starfish may get nipped between the valves of a gaping mollusc. And so it comes to be that starfish are frequently caught by an arm. But it is better that a limb should be lost than that the whole body should be sacrificed. On this principle the starfish breaks off the arm which is seized and creeps away. And then in due time a new arm grows and replaces the old. As many as four out of the five arms can be replaced in this way. Now, I think you can answer the question: What is the meaning of the comet starfish? It is a starfish which is regrowing lost arms. Keep a sharp lookout for "comets" when next you visit the seashore.

I have not told you all the story of the starfish, but this will do for the present. When you are older you may hear something about its babyhood, which is very different from its fully grown state. But you might notice that there are other kinds of starfish besides the common one of our coasts. Two other common ones are the **sun-star** and the **cushion-star.** Do you know these?

You should draw a starfish, upper side, and name the various parts. Think well over all you have heard and seen and write down an answer to these questions:

How does a starfish breathe?
How does it move?
How does it feed?
How does it keep its body clean?

LESSON LXXX.

SPONGES.

[Specimens:—	School Sponge.	(Bath Sponge.)
	"Mermaid's Gloves."	Trawlers find these in British waters.
	Bread Crumb Sponge. Purse Sponge.	Found between tide marks on our own shores—Rocky coast.
	Venus Flower Basket. Glass Rope Sponge.	These may be seen in most Museums.

A lesson may be taught from the bath sponge alone.]

Is it difficult for us to realise that a sponge is an animal? Perhaps it is at first. It becomes easier when we learn that there are a good many other animal forms which are sedentary and more or less plant-like in their habit of life. And it will be still easier when we have examined some sponges and asked and answered some questions regarding them.

The sponge as we know it and use it for washing our hands and faces is not the whole animal. If we could see the sponge when it is brought to the surface of the sea we would not see the fibrous substance we use at all. This is really an internal part which is surrounded by a softer, fleshy substance in which we can see numerous openings leading into the interior. We shall recall these openings later on.

We may quite properly then speak of two distinct parts in a sponge. There is a soft part which we call the "**flesh**" of this animal, and a tough or hard part, the fibres or "**skeleton.**"

The Hard Parts.—When we examine other sponges, *e.g.* those we find upon the seashore of our own country, we find the same distinction of a fleshy part and a hard part. We find, however, that the hard parts differ in different sponges. When a "purse" sponge, for example, is placed in weak hydrochloric acid, the whole of its hard part disappears. In this case the "skeleton" consists of a framework of sharp pointed rods of **carbonate of lime** which dissolve in acid. The "crumb of bread" sponge, on the other hand, has its hard part composed of clear glassy needle-like rods of **flint** (silica), which do not dissolve in acid. The mermaid's glove has both a **horny and flinty** skeletal portion. The "Venus' flower basket" is a delicate and beautiful framework of clear glassy needles of silica. It lives in the deep waters of tropical seas, but examples are to be seen in most museums. The hard parts not only support the softer flesh, but they serve to prevent the sponge being eaten by other animals.

Surface.—When we look closely at the surface of the complete bath sponge we see a number of fair-sized holes. If we examine it further with a good lens we discover a far greater number of quite minute openings. The surface of a sponge is in fact riddled with innumerable pores. All sponges have these **two kinds of openings,** the large and small. Some, like the purse sponge, have only one large opening. Such a sponge is termed a simple one. Most are compound, having many large openings. Familiar examples are the bath sponge and the "bread crumb."

Water Currents.—When a small piece of carmine is placed beside a living sponge in a vessel containing sea water an interesting sight may be witnessed. The colour of the carmine gradually spreads in the water and draws off towards the sponge. It is evidently being sucked into the body of this strange old-fashioned animal. Presently, if this experiment succeeds completely, it will be noticed that the coloured substance is now leaving the sponge by way of the large openings. What does this simple experiment teach? It shows us that a **living sponge creates currents in the water** in which it lives, drawing the water through its body, inwards by very many small openings, and outwards by the large visible ones.

Use of these.—Can we guess what is the use of this? A sponge is a *fixed* animal. It is unable to move about seeking food. In drawing water through its body, it thus makes the water carry its food. The washing of the body, too, enables the sponge to breathe, and when young sponges are formed within the parent the outward flow of water carries them off to live somewhere else.

Direction of Flow.—Perhaps you wonder why the water is made to flow in at the very small openings rather than by the larger. Since the water is carrying the food, some of you may think the sponge would get more and larger particles if the water flowed the opposite way. But the sponge's organs for feeding are very delicate and can deal only with extremely small particles of food, viz. microscopic plants, and larger bodies such as might find a passage inward by the larger openings could not be used. Then as they could not pass out through the small pores, the sponge body would gradually get blocked up with useless and harmful substances which in the end would kill the sponge.

Cause of the Currents.—What is the cause of the flow of water? Within the sponge, lining the walls of the passages here and there, are great numbers of delicate **hair-like lashes** (flagella), which move constantly backwards and forwards, so as to cause the water to flow always in the one direction.

A piece of ordinary bath sponge is full of winding passages, and you may think these correspond to the passages which abound in a living sponge. But that would be true only in a very general way. Round all the fibres of the living bath sponge there lay soft flesh, and the passages in this were much narrower and more numerous than those you now see.

Sponge is an Animal.—Perhaps you are still wondering why we call the sponge an animal. It is not, of course, like most of the animals we know, although there are many undoubted animals which have the same fixed or sedentary habit. I think the answer which will satisfy you best, however, is that the sponge deals with its food in the same way as animals do and not as plants. They digest solids, whereas plants feed on substances dissolved out of the soil or water, and gases.

ZOOLOGICAL SUMMARY OF WINTER ANIMAL STUDIES.

The subjects dealt with in the foregoing chapter have all received fairly full treatment, and no further notes require to be made other than to arrange the types in systematic order and to make cross references to the classification given in the Appendix.

Porifera.—Sponges. A simple sponge is a vase-like structure, having many inhalant pores in its walls and a single exhalant opening—osculum. Sponges multiply by means of sexual bodies and asexually by budding.

Their feeding and respiration have been referred to. See also p. 457.

Echinoderma.—Starfishes. See p. 455.

Crustacea.—Crabs. They belong to the division Decapoda (ten-limbed) and sub-division Brachyura (short-tailed). Their cuticle consists of chitin, together with carbonate of lime. It is usually pigmented. They have mostly two pairs of antennae. Compare with insects in these two particulars. See p. 420.

Insecta.—The Orders of the various insects considered are given in the lessons.

Pisces.—All the fishes referred to in the lesson are bony fishes (Teleostei).

Aves.—The robin (*Erithacus rubecula*) is a member of the Order Passeres, commonly termed Perchers, and of the Family Turdidae, which comprises the thrushes, blackbird, redstart, nightingale, and some others.

Mammalia.—The place of the various mammals referred to may be ascertained from the Table given in the Appendix.

QUESTIONS ON CHAPTER VIII.

(WINTER ANIMAL STUDIES.)

1. What are the chief features about winter which render the lives of animals difficult? Name some of the principal ways in which animals make winter easier for themselves.

2. Name some common hibernators. What are the chief features about the hibernation of the squirrel, hedgehog, and bat?

3. Name six general facts about hibernation.

4. What are the general characters of birds' bones.

5. What is the use of the keel upon the breast bone of a flying bird? State what is the bony connection between the breast bone and shoulder girdle in birds.

6. Name two distinctive features about the back bone of a bird. What is the particular value of each?

7. Name the chief groups of feathers upon the wing of a bird.

8. What bone supports the secondary quill feathers? How many digits are there in a bird's wing?

9. State four facts of special interest regarding robins.

10. Make an outline drawing of a trout, naming all the fins and other structures represented.

11. Show how the shape of a fish is adapted to its aquatic life.

12. Make a drawing of a chrysalis of the cabbage butterfly and name the parts visible upon it. How does it breathe?

13. What is the meaning of the term "chrysalis"? Why is it applied to the pupa of a butterfly?

14. Name four distinguishing external features characteristic of insects.

15. What is meant by protective resemblance? Give an example.

16. What is meant by "mimicry"? Give an illustration.

17. What is the form assumed by the young of the following insect types: Fly, beetle, moth, cockroach?

18. Distinguish a cockroach from a black beetle.

19. State the nature of the breathing organs in a crab. Where are they situated? How does a crab breathe out of water?

20. What is a crab's "purse"? What use is made of it by the female crab?

21. What is a "masking" crab? What is the meaning of masking?

22. Make a drawing of a common starfish and name as many parts as you can.

23. What is the use of the "water-plate" upon a starfish? Where are its eyes and mouth?

24. What happens when a starfish loses an arm? How does it open a mussel?

25. Name two things effected by the flow of water through a sponge. What is the advantage in the inward flow taking place through the more minute openings?

26. What do the skeletal parts consist of in the bath sponge, the purse sponge, and in Venus' flower basket? Why do we regard sponges as animals?

CHAPTER IX.

SCHEMES OF STUDY.

With the view of assisting teachers to make the work in Nature Study systematic and constructive the following schemes of study in particular groups have been drawn up. Part of all of these is incorporated in the studies already given. The teacher, with the help of these schemes, will be able to vary the work in successive years by substituting parts previously omitted. The schemes should be used in summarising and revising work to ensure fairly complete knowledge of particular subjects and thus avoid "scrappiness." The schemes may also be used profitably by teachers obliged to give a limited amount of nature study and who wish not to roam over the whole field but to specialise in a group or groups, *e.g.* Trees and Birds. Such work does very well with higher classes who have done elementary general work. For such the schemes will probably need extension, but they will serve as suggestions. A scheme of Flowering Plants is not included here. These have received reasonably full treatment in the text.

SUGGESTED SCHEME OF STUDY OF TREES THROUGHOUT THE YEAR.

Spring.

1. *Study of Buds.*—The buds upon Trees conveniently situated should be examined at regular short intervals; twigs of a series of Trees should be placed in water indoors. In both cases the swelling of the buds, the fall of the scales, and the unfolding of the leaves is to be noted, and suitable drawings attempted. A series of stages

should be got. Note bud characters in a representative set. Transition stages, leaf to bud scale in Horse-chestnut to be noted.

2. *The Young Leaf.*—Appreciative examination of young leaves, noting texture, colour, etc. Special features, *e.g.* Horse-chestnut, all stages of folding of leaflets. Drawings.

3. *Flowers of trees in Spring.*—Examination of such of the following as are available in the locality:—

> Hazel, Alder, Elm, Yew, Willow, Birch, Beech, Oak, Ash, etc. In each case the *time of flowering* to be noted, whether the *flowers appear before the leaves*, whether *male and female flowers are upon the same plant*, whether *wind* or *insect pollinated. Drawing of male and female catkins of willow, etc.*

4. *Seedlings.*—Planting; search for seedlings out of doors. Examination, with drawings, of seedlings of Sycamore and Ash or other common trees.

5. Notes upon the young cones of the Larch and the male cones of the Scots Pine.

6. Study of a Shrub, *e.g.* Rhododendron, Flowering Currant.

Summer.

1. *The Tree as a whole.*—An attempt to appreciate the general contour of trees in relation to habit of branching. Recognition of rounded, oval, pyramidal, conical forms. The relative amount of shade under different kinds of tree, and the type of vegetation below.

2. *The fully formed Leaf.*—Recognition, with drawings, of the leaves of all available trees. Their shape and arrangement upon the branch to be noted; leaf mosaics to be recognised upon individual branches and upon the tree as a whole. The relation of leaves to light to be understood and appreciated as a result of these studies.

3. *The Tree Trunk.*—Recognition of the tree by its bark in a few clear cases. What may be seen in a cross section of a trunk or large branch.

4. *The Later Flowering Trees.*—Sycamore, Rowan, Hawthorn, Lilac, Horse-chestnut, Lime. Inquire as to pollination of these. Insects visiting trees.

Autumn.

1. *Leaves in Autumn.*—Comparisons as to order and times of change. Appreciation of autumn coloration of the tree. Following the colour changes upon the leaf.

Drawings.
The fall of the leaf explained.
Note leaf-buds for next year.

2. *The Formation of Leaf-mould.*—The passage of the organic back to the inorganic.

3. *Tree Fruits and their Dispersal.*—(Note that this has been going on since April.)

Winter.

1. *The Bare Tree.*—Appreciation of form and tracery of naked branches against the sky. The shape once more.

2. *The Twigs.*—Recognition of the commoner trees by their twigs, bud form, and arrangement.

Detailed study of one or two twigs with drawings of these.

3. *Study of an evergreen.*—The spruce tree. Notes on evergreens generally. Leaf characters and their meaning in relation to winter.

4. *Cones.*—A study of the cones of Larch, Pine, and Spruce, with drawings of each.

5. *Lichens and other growths on Trees.—Healing of scars.*

SCHEME OF STUDY OF BIRDS.

The bird life of our country is one of the chief attractions of wild Nature both for children and adults, and in all schemes of Nature Study it ought to receive important consideration. As flowers amongst the plants impel the interest and dominate the outlook upon the vegetable kingdom, so do the birds amongst the animals charm our fancy and engage our most willing attention, and no course in Nature Study is complete which does not contain a well considered scheme in both types of life.

All vital work in Nature Study inevitably extends its sphere beyond the classroom. We can, of course, study birds, as other living forms also, in the classroom alone, but such work is incomplete and fails in one of our fundamental aims if it does not interest the child in bird life out of doors, to the extent of stimulating his or her observational faculties upon all the birds of the neighbourhood.

We include, therefore, in our proposals for bird study, proceeding from the schoolroom but not stopping there, the suggestion—

1. That all through the year pupils and teachers alike will endeavour to know at sight the birds of their district. A list of the birds of the district should hang upon the schoolroom wall. In a town the birds of the town should be similarly listed. As the teachers and pupils get to know the birds at sight, other facts of interest about them should be sought and will gradually be acquired, such as their song (if any) and the recognition of the bird by it, their characteristic flight, their nest and egg, migratory and feeding habits.

2. Within the school, lessons should be taught upon various elements in the structure of birds, an understanding of which will help the child to better appreciate their life. Such lessons might include, *e.g.*, the following:—

The plumage of birds, variety of coloration in birds, some of it protective, some decorative; its value in flight in giving contour to the body, and in actively promoting it as in wings and tail—its value as a non-conductor of heat, etc.

The structure of a feather.

The bills and feet of birds in relation to feeding habits and to habitat.

The senses of birds, illustrated in their eyes, cere, ears, and nostrils.

The wing of a bird, in detail—its history and present use.

Some common bird bones, and what we can learn from them, *e.g.*—

Breast bone of a fowl.
The shoulder girdle.
The back bone.

3. Lessons on the Eggs of Birds.
   - (*a*) *An egg* in detail—the uses of all the parts.
   - (*b*) *The colour of birds' eggs*, and what they mean.

4. Studies of particular birds, chosen to illustrate in each case some special feature of bird life. The whole natural history of the bird may be of course dealt with in the lesson, but the bird will be selected with special reference to one aspect of bird life which it more particularly illustrates, and this aspect should be the dominating theme in the lesson. Examples are here given:—

*(*a*) Swallow; Swift; illustrate powers of Flight, also Migration: Summer Visitors.
*(*b*) Lark; Nightingale; Blackbird; Thrush—Power of Song.
*(*c*) Lapwing, etc.—Parental care.
*(*d*) Ptarmigan; Curlew; Woodcock — Protective Coloration.
*(*e*) Goldfinch; Linnet; Chaffinch—Nest building.
(*f*) Owl—Nocturnal Habit.
(*g*) Sparrow-hawk; Kestrel—Predatory Habits.
(*h*) Cuckoo—Parasitic Habit.
*(*i*) Fieldfare; Redwing—Winter Visitors (Migration again).
(*j*) Wood Pigeon; Rook—Importance in Agriculture.
(*k*) Gulls; Guillemots; Puffins—Sea-birds.
*(*l*) Redbreast; Starling; Tits—Resident all the year.
(*m*) Crow, Rook, Jackdaw, Magpie, etc. Sparrow-hawk, Kestrel, Merlin — Examples of Bird Families.

Where more than one bird is given a choice can be made. Those marked * constitute a scheme in themselves, covering the essential features of bird life. The others amplify and supplement these, and might well be included in a second year's course, along with any others occurring to the teacher. The particular examples quoted above need not of course be taken if the theme can more conveniently be illustrated by others. But those quoted have been carefully selected as specially appropriate.

THE WORK DISTRIBUTED OVER THE SEASONS.

The seasonal aspect of bird studies must not be overlooked, and having outlined the subject-matter desirable to be included in a school course, we shall now indicate how best to distribute this work over the seasons.

The following may be made to extend over two years:—

Spring.

Migrant Arrivals—Types to Study—Swallow, Swift—with note on Cuckoo and Corncrake (heard but not so often seen).

Illustrate Powers of Flight in Types quoted.

Natural History of Birds having some particular association with Spring, *e.g.*—

Rooks—Early mating in Spring.
Lark—Song in Spring.
Lapwing—Young Birds in Spring.

Summer.

Study of Eggs.
Singing Birds—Select from Nightingale, Thrush, etc.
Neat Nest Builders—Linnet, Chaffinch, etc.
Cuckoo.
Wood Pigeon.
Birds of Prey.
Gulls.

Autumn.

Migration again—Observational notes on birds preparing to leave.
Lesson on Owls.
Some structural studies, *e.g.* Plumage—Feather, etc.

Winter.

Winter Visitors—Woodcock, Fieldfare, Redwing.
Feeding observations—Resident Birds, *e.g.* Robin, Tits.
More structural studies, *e.g.* some Bones.
Studies of Family Groups—Crows, Gulls, Hawks, etc.
Protective Coloration, *e.g.* Ptarmigan, etc.

SCHEME OF STUDY OF INSECTS.

Spring.

In this season insect life is not very obtrusive, it be best known to children in the freshwater ponds or in the school aquarium.

Study behaviour, structure in relation to habits, and life-history of Gnats, Whirligig and other Water Beetles, Caddis-flies, etc.

Larvae of terrestrial insects may suitably be studied here, such forms as appear early should be noted. Crane-fly larvae ("leather jackets") in fields. Caterpillars which have wintered as such, *e.g.*

Surface Caterpillars in soil.
Magpie Moth Caterpillars may be looked for and their condition noted.
Beetle larvae will be found in soil, *e.g.* "wireworms."

Short lessons will be sufficient. Caterpillars are best done in detail in summer, when more variety can be got.

Early visitors to flowers should be observed. Humble-bee Queens and Wasp Queens, Hive Bees, should all be watched for, and the story of what they are doing at the time should be told. The full life-history of the Wasps should be given later.

Summer.

Caterpillars. Life, habits, and structure. Identification of all examples found by pupils. Rearing in Cages.

Butterflies. Life-history, habits, structure. Identification of all Moths and Butterflies found.

Bees. The economy of a Beehive. Structure and life-history of the Bee.

Inter-related studies. Flowers and Insects, particular cases to be taken.

An inquiry into the habits of house flies. Recognition of the commonest insect types visiting flowers (Hover-flies) or doing damage in field or garden, *e.g.* Green-flies, Leaf-roller Caterpillars, Sawflies.

Note on useful insects, *e.g.* Lady Birds.

Autumn.

Field observations on Hover-flies.
Life-history of Wasp.
Structure and life-history of Crane-fly.
Observation and identification of Moths.
Observations on the industries of Ants.

Winter.

The structure of insects. Characters of common types, with outlines of life-histories. Bee, Fly, Beetle, Butterfly, Cockroach, Bug.

Winter life of insects. Particular case the Chrysalis of the Cabbage Butterfly—the meaning of the resting stage.

A general summing-up of the significance (in many cases) of insect form and colour should come into the scheme at some point. Protective resemblance, warning colour, and mimicry should be illustrated by reference to particular cases, *e.g.* Crimson Underwing Moth, Wasps, Hover-flies.

SCHEME OF STUDY OF MAMMALS.

Spring.—A general study of the Mammals of our country, beginning with a list of these—names to be supplied by pupils, supplemented by teacher. The grouping of them in relative (approximate) numbers—in distributional regions, *e.g.* wild and remote parts of country (Wild Cat, Polecat), near human dwellings or lands (Weasels, Rats, etc.), and so on. General relations to human interests, important and unimportant, etc. Simple account of fundamental features of group, structural and other.

Study of some Mammals whose activities become noticeable at this season, *e.g.* Hares, Lambs, Moles. The study of the Mole should deal with its adaptive characters in relation to its burrowing habits.

Summer.—A choice of types depending on circumstances. The following are suggested :—

Hedgehog (fairly common, and most active at this season). Shrews. Voles. Rabbits (young rabbits available in summer season). Weasels and Stoats.

Two aspects of summer life to be emphasised in particular—feeding and care of young.

Autumn.—Providing for winter—Squirrels (storing), Dormice and others (fattening).

Harvest Mouse. Rat. Water Vole. Bats.

Autumn habits of forms studied in other seasons.

Winter.—How the various types get through the winter.

Hibernators—Dormouse, Hedgehog, Squirrel, Bats.

Active hunters in winter, *e.g.* Stoat.

Enemies of our smaller mammals : Owls, Hawks. Other mammals, *e.g.* Weasel and Stoat.

Mammals in the service of man, *e.g.* Dog and Horse. Association with man in early times, probable beginnings of domestication—Wild relations.

Simple classification : Noticeable features of—

Carnivores. Rodents. Insectivores. Ungulates.

CHAPTER X.

A BIRD'S-EYE VIEW OF THE ANIMAL KINGDOM.

The object of this survey of the living forms of animals is to provide for the reader untrained in systematic zoology a means whereby he may secure an orderly view out of the rather perplexing confusion which accompanies a first familiarity with the numerous forms of life which abound on every hand. One of the surest things to give both confidence and authority in teaching is the knowledge, not necessarily to be imparted, of the place amongst all the other forms of life of any animal which may be the subject of class study. A true perspective is essential to the most effective work, here as in other studies.

On the principle of proceeding from the familiar to the less familiar we commence not at the bottom of the scale of life, which doubtless is the more logical order, but at the top of the animal series. By so doing we are the more likely to effect the purpose we have in view.

MAMMALS.

The highest grade of animal is that known as the mammalia. These are the animals familiarly known as quadrupeds, most of which have a very complete covering of **fur** or hair. Perhaps amongst the numerous distinguishing features of this group the most important are the relations between the **unborn young** and the mother, the nourishing of the young after birth with the **milk** secreted by the mother, associated with marked **parental care.** Further, on the whole the **brain development** of mammals is higher, together with sensory acuteness, and a varying preponderance of **intelligence in action** as compared with other forms. There are also other characteristics, such as the presence of **sebaceous** and **sudorific** glands in the skin, and a **muscular diaphragm** separating the chest from the abdominal cavity, which are distinctive.

Mammals are terrestrial animals, but the group includes forms which secondarily have adopted an aquatic, a semi-aquatic, or an aerial existence. In some of the aquatic types the covering of hair is more or less reduced, but hair is never completely absent. Typical examples of mammals are quoted in the appended Table of Classification.

BIRDS.

A second highly important grade of animals is that of **Aves,** the birds. While these are so familiar as to render description unnecessary, it may be as well to mention a few of the more important structural peculiarities. Besides the possession of a covering of **feathers,** and having fore-limb modified so as to serve as an **organ of flight,** the entire **absence of teeth** in all living forms, the ensheathing of the jaws in a **horny bill,** the **scaly feet,** and the maximum of **four toes** are other external features which may be noted.

The skeleton has many peculiarities of interest (p. 398), most of which are adaptations to the flying habit. In their degree of **brain development** and in their **emotional life** as exhibited in their manner of mating, singing, and rearing of young they rank along with mammals on a distinctly higher plane. The success in life of birds is well attested both by their actual numbers and by the very large number of species which exist.

REPTILES.

Next in order comes the grade of reptiles. These do not form such a coherent group as do the higher types. In the past Mesozoic Age these were much more numerous and varied than they are to-day. Of living forms there are five distinct types. These are the **crocodiles,** the remarkable *Hatteria* or New Zealand lizard, true **lizards, snakes, and tortoises.** The reptiles of the British Islands are limited to six, viz.: three snakes—the **grass or ringed snake** (*Tropidonotus natrix*), the **smooth snake** (*Coronella laevis*), and the **adder** (*Pelias berus*); three **lizards**—the **grey lizard** (*Lacerta agilis*), the **viviparous lizard** (*Zootoca vivipara*), and the **limbless lizard** (*Anguis fragilis*).

Reptiles are widely distributed throughout the world, they are most numerous in tropical or sub-tropical lands and waters, and have in snakes their most numerous representatives. They are **cold-blooded**—that is, their temperature is but slightly or not at all higher than the surrounding medium; they possess a **scaly exterior**; they resemble birds and mammals in having before being hatched **two important foetal membranes,** the amnion and allantois; they differ from the next group in never, at any stage of their life-history, possessing gills.

AMPHIBIANS.

Next in order, as far as structural development goes, are the Amphibians. These are the **frogs, toads, newts, salamanders,** together with some widely distributed burrowing worm-like **limbless forms.** These animals mark in the scale of vertebrate life an ascent from aquatic to terrestrial life, an ascent which is repeated in the course of their life-history in greater or less detail in the majority. Of this the life-history of the common frog is the best and fullest example (pp. 62, 209). There are six British amphibia, viz: the **common frog** (*Rana temporaria*), the **common toad** (*Bufo vulgaris*), the **natterjack** (*Bufo calamita*), the **common newt** (*Molge vulgaris*), **palmated newt** (*Molge palmata*), and the **great water newt** (*Molge cristata*).

Nearly all amphibians have **gills** in their larval stages at least, and as larvae many are in all important features fish-like in structure and habit. But at least two important characters of terrestrial animals appear in this group for the first time in the scale of animal life, viz. **true**

lungs, which all acquire, and limbs having **fingers and toes,** which all (except the degenerate limbless forms) possess as adults.

FISHES.

These are a prolific race, rich in numbers and in species. Like the reptiles and amphibians, fishes are **cold-blooded,** their breathing organs are **gills,** borne upon arches at the sides of the head, their limbs are **fins,** and serve mostly for steering and balancing rather than propulsion, which is effected chiefly by the tail. Typically they possess **scales** and have numerous glands and sensory structures upon the body. The **lateral line,** prominent upon many common food fishes, is such a structure.

In general organisation they are simpler than the forms already reviewed, *e.g.* their **heart** consists of only two chambers and contains **venous blood** only. There are, however, three types of fish, living respectively in South America, Africa, and Australia, known as **"mud-fishes,"** which have a rudimentary three-chambered heart, nostrils opening into the mouth, and a rudimentary lung. Thus they are functionally transitional between fishes and amphibians, but they are probably not directly genetically related.

Apart from these mud-fishes or Dipnoi as they are termed (double breathers), there are three great groups of fishes. These are:—

The **elasmobranchs** or gristly fishes—the sharks and rays (skates), etc.

The **ganoids**—the sturgeons, the bony pike of North America, etc.

The **teleosteans** or bony fishes, *e.g.* salmon, eel, cod, herring, etc.

The foregoing groups—mammals, birds, reptiles, amphibians, and fishes—constitute the Vertebrata or backboned animals; but before passing on to consider the Invertebrata, it falls to us to mention the existence of several types which in their structure or development serve to bridge over the gap between these two divisions. The **Cyclostomes,** or Round Mouths, represented by the

lampreys, the hagfish, and a few other forms, are distinctly vertebrate in their plan of structure, although they possess in place of a backbone an unconstricted cartilaginous rod, known as the **notochord,** or dorsal rod. The interest of this structure lies in the fact that all the true vertebrates possess it also, but in their case it is confined to the embryonic stage of existence, being supplanted later by the true backbone. The " round mouths " are further, as the name suggests, devoid of jaws, which structures are characteristic of true vertebrates, and they have other peculiarities.

Besides these there are other simpler forms, such as the **Amphioxus,** or **Lancelets**, the **Sea Squirts** (Tunicata), and the worm-like creature known as **Balanoglossus,** all which exhibit signs suggestive of affinity with the vertebrate type. These all show in greater or less degree a "notochord," and for this reason it is more correct to speak of all these types up to the Mammalia as **Chordata** rather than Vertebrata, and all the remaining animal forms as **Non-chordata.**

Passing now to the invertebrates, or non-chordates, we find it is not possible with the same certainty to group the various classes in a natural series. It is usual to place at the top the forms known as

MOLLUSCA.

These constitute a rather diverse group both as regards structure and habits. They are the Bivalves, such as oyster, mussel, etc.; Gasteropods, *e.g.* the snails and slugs; Cephalopods, or cuttlefish; *Dentalium*, or tooth shells; and the Amphineura, primitive forms. Most of these possess a concentrated type of nervous system, consisting of at least three pairs of ganglia. They possess a muscular protrusion upon the ventral surface, termed the **foot,** which serves in the majority as an organ of locomotion. In most cases a single or double fold of skin, called the **mantle,** secretes a protective **shell.** Though not possessed by all, a chitinous toothed ribbon, termed the **radula,** used for rasping the food, is characteristic of the group.

In general, molluscs are sluggish animals. Their relationships are uncertain; most probably they are derived from the ancestral types which gave rise to the unsegmented worms.

ARTHROPODA.

An important series is that of the Arthropoda, or jointed-limbed invertebrates. It includes the **Crustacea,** which are for the most part aquatic, breathing by gills or through the skin. They are the **crabs, lobsters, water fleas, fish lice,** etc. They have a hard outer crust of carbonate of lime, and carry two pairs of feelers upon the head. Most crustacea are carnivorous and predatory, some feed on dead creatures and organic débris in the water, a few feed on plants, and there are numerous parasites, and some commensals, *e.g.* hermit crab and sea anemone. Pelagic minute forms (Entomostraca) occur in enormous numbers, and form an important element in the food supply of fishes. The class **Myriapoda,** another division of the Arthropods, comprises the **centipedes** and **millipedes.** The former, which have a pair of legs to each segment of the body, are both carnivorous and poisonous; the latter, with two pairs of legs to each segment, are vegetarian, and very destructive to cultivated plants.

The **Insecta,** another division, comprising more species than there are of all other animals combined, are an important group of diverse habits, having many and complex relations with other forms of life and of human activity. They are structurally similar to the myriapoda, but exhibit concentration and grouping of the body segments, have fewer and more specialised appendages, and many possess wings. On the whole, also, their instincts are more varied and specialised.

The group of **spiders, scorpions, mites,** and **ticks,** known as the **Arachnoidea,** form another section of the Arthropod phylum. They exhibit greater concentration of the body regions than insects, and, apart from their tracheal breathing apparatus, resemble them but slightly. Of several aberrant orders, probably related to these, one may be mentioned, viz. the Tardigrada, or **Water Bears,** microscopic creatures to be found in dust, amongst moss, etc.

Very diverse in form and habit as the various types of Arthropods are, the group as a whole is remarkably well defined and marked out by the possession of, amongst others, the following characters. The skin is strengthened by a cuticle of chitin; the body carries a series of paired appendages, which are jointed; it is divided into segments, and the symmetry is bilateral. The nervous system consists of a brain situated above the gullet, a nerve ring around the latter connecting the brain with a double chain of ganglia which passes along the ventral surface. Economically the group is of considerable importance.

ANNELIDA.

Possessing fundamentally the same plan of structure, and very probably related, are the Annelida, or ringed worms; in symmetry, segmentation, and type of nervous system the two groups are alike. An important structural feature also in the Annelida is the body cavity, the space between the body wall and the gut. Beginning amongst lower types, it is first clearly seen in the Annelids. The group embraces several types of diverse habits and structure. As examples of the bristle-footed worms, or **Chaetopoda,** may be quoted the familiar **earthworm** and the **fisherman's lobworm**. These may be regarded as typical, but there are various modified sedentary forms, e.g. *Serpula*, etc. The leeches, or **Discophora,** are probably Annelids which have become modified in consequence of their semi-parasitic habits. Here may be mentioned the Polyzoa, *e.g.* the seamat, and Brachiopoda, or lampshells (Podaxonia).

ECHINODERMA.

These constitute a well defined series. They are the **starfishes, brittlestars, featherstars** or sea lilies, **sea-urchins,** and **sea-cucumbers.** They exhibit radial symmetry in the adult condition, but that of the larva is bilateral. A characteristic structure is the water vascular apparatus, a system of vessels containing a watery fluid subservient to locomotor and respiratory purposes. There is a marked tendency towards the deposition of lime in the tissues. Their development is "indirect," the adult. developing as a new growth upon the tissues of the larva. Most members of the group practise self-mutilation or **autotomy** in unfavourable circumstances, *e.g.* the yielding up of the arms by many starfish on capture. This practice is associated with the power of regenerating the lost parts. The Echinoderma are all marine.

In addition to the Annelids already referred to, there falls to be mentioned a somewhat varied and heterogeneous collection of "worms." They agree with the Annelids in possessing bilateral symmetry, but they have no appendages and are unsegmented. Of these the most important are the **Nematoda** or threadworms and allied forms, many of whom are parasitic in plants or in animals; also the **Flatworms,** embracing the free-living Turbellaria, the parasitic Flukes or Trematoda, an example of which is the important parasite the liver-fluke of the sheep (*Distomum hepaticum*), and the Tapeworms or Cestoda. Here also are placed the marine Ribbonworms or **Nemertea.** At this point we have reached in our descent of the animal scale another stage in the developmental history of animals. The feature of bilateral symmetry, the possession of a body cavity, the presence of three embryonic layers (ectoderm, mesoderm, and endoderm), are distinctive characteristics in a more or less clearly defined degree of all the foregoing animal types.

COELENTERATA AND PORIFERA.

The remaining multicellular animals are more simply organised. These have no body cavity, the only internal cavity is that of the food canal. The **radial symmetry** of the embryo persists in the adult, and there is no definite middle cellular layer (mesoderm), but only in some a middle jelly (mesogloea). Coelenterata are **zoophytes, jellyfishes, sea anemones, corals.** They are mostly marine. The body may be a tubular polyp or a bell-like "medusoid"; in some there is an **alternation of generations** between the two types. Asexual multiplication takes place by budding and fission; in the latter case many have limy skeletons which form corals. The Porifera or sponges are the simplest many-celled animals, but their simplicity is generally disguised by budding, folding, etc., and by the presence of supporting skeletal parts of a horny, limy, or siliceous nature.

This concludes our survey of the multicellular animals, the Metazoa. We have now reached another important stage, the transition to the Protozoa, animals which within the compass of a single cell perform all the necessary functions of life, from the Metazoa, which, dividing the labours of the body, have distributed the various functions amongst various groups of cells more or less appropriately specialised.

PROTOZOA.

These are the simplest of animals, and are usually only single cells (*i.e.* unit masses of living matter, mostly microsopic). Even when they form colonies of cells, each cell is functionally similar to its neighbours; there is no differentiation (except in a few cases for reproductive purposes) of parts comparable to the Metazoan "body." They are almost exclusively microscopic, very diverse in the form of their cell, many of which, *e.g.* the **Infusoria,** exhibit much specialisation of parts. Many again have a skeletal framework of lime, silica, or other substance. In some cases these "skeletons" form extensive deposits, *e.g.* the chalk-forming **Foraminifera** or the **Radiolarian** "Barbados earth." There are many forms which are parasitic, and of considerable importance to man on this account.

The life-histories of the Protozoa are very diverse, and in some, especially the parasitic forms, extraordinarily complex, involving more than one host. The Protozoa are further of interest and importance for the light they throw upon the beginnings of life itself. They merge by imperceptible transition into those Protista which link them to the lowest plants, and which themselves are the lowliest of known organic forms.

NOTES WITH REGARD TO BEGINNINGS OF VERTEBRATE OR CHORDATE STRUCTURES.

Notochord.—This structure is first seen in the so-called Primitive Vertebrates (Lancelet, Sea squirt, etc.). In these and in the Cyclostomes it is the only dorsal axis, at no period being replaced by a backbone.

Backbone.—This structure first appears amongst fishes. In the gristly fishes (shark, etc.), although segmented, it does not consist of true bone. In all cases where it appears it is preceded by the notochord.

Paired Limbs.—In fishes these are fins. No other forms possess them. In Amphibia, limbs with fingers and toes appear for the first time. The limbs of all higher forms are of this *type*, whether used in air, in water, or on land.

Lungs.—A modification of the air bladder serving as an additional respiratory organ occurs in the mudfishes. The true lungs of Vertebrates are those appearing in Amphibia.

Nostrils.—In fishes these are olfactory only. In Dipnoi and Amphibia respiratory nostrils (in association with the coming of lungs) are established.

Skull.—All chordate animals from Cyclostomes upward possess a skull. In development and fundamental plan of structure it is the same throughout all the groups.

Jaws.—Neither Cyclostomes nor Primitive Vertebrates possess jaws. These occur, however, in all the higher chordates, viz. fishes to mammals.

OUTLINE CLASSIFICATION OF ANIMALS

(WITH PARTICULAR REFERENCE TO THE BRITISH FAUNA).

CHORDATA

(Equivalent in most cases to Vertebrata).

MAMMALIA.

The Bats (p. 338),		**Cheiroptera**	With fore limb adapted for flight.
Hedgehog, Mole, Shrews (pp. 178, 237),		**Insectivora**	With teeth adapted to insect diet. Back teeth with pointed tubercles.
Wild Cat,	Cat Type,	**Carnivora**	Flesh eaters.
Fox,	Dog Type,		
Otter, Badger, Weasel, Stoat, Polecat, Marten,	Bear Type,		
Seals and Walruses,	Marine Carnivora,		
Beaver, Squirrel, and Dormouse, Rats, Mice, Voles (pp. 329, 333), Guinea-pigs, Hares and Rabbits,		**Rodentia**	Gnawers, with chisel-edged front teeth (incisors). Teeth grow throughout life.
Pig, Camel, Deer, Ox, Sheep, Goat, Horse, Elephant,		**Ungulata**	Hoofed Animals.
Whales, Porpoises, Dolphins,		**Cetacea**	Aquatic Mammals, fish-like in form, without hind limbs.

AVES.

The following list contains the names of fifty Common Birds representative of the Orders occurring in Great Britain :—

Sparrow Hawk, Kestrel.
Tawny Owl (p. 324).

AVES (*continued*).

Song Thrush, Blackbird, Dipper, Wheatear, Redbreast, Goldcrest, Wren, Bluetit, Pied Wagtail, Swallow, Martin, Greenfinch, House Sparrow, Chaffinch, Yellowhammer, Corn Bunting, Bullfinch, Skylark, Jackdaw, Rook, Carrion Crow, Hooded Crow, Magpie, Starling (p. 188).
Cuckoo, Swift (pp. 90, 99).
Heron.
Wild duck.
Ring Dove (p. 182).
Partridge, Red Grouse.
Corncrake, Moorhen.
Lapwing (p. 86), Snipe, Dunlin, Sandpiper, Redshank, Curlew.
Common Tern, Herring Gull, Kittiwake, Blackbacked Gull Blackheaded Gull.
Guillemot, Razorbill, Puffin.

REPTILIA.

Grey Lizard, Viviparous Lizard, Limbless Lizard.
Grass Snake, Smooth Snake, Adder.
Crocodiles.
Tortoises and Turtles.

AMPHIBIA.

Frogs and Toads }
Newts and Salamanders } (p. 72).

PISCES.

Shark, Dogfish, Skate.
Carp, Salmon, Pike, Eel, Stickleback, Perch, Cod (p. 409).
Mud-fishes (Double breathers).

CYCLOSTOMI :—Round mouths. Fish-like forms, without jaws, paired fins, or scales.

Lamprey and Hagfish.

Besides the foregoing there are also ranked as Chordata the Lancelet, Sea-squirts, and a few other forms which exhibit more or less clearly Chordate affinities.

NON-CHORDATA

(Equivalent to Invertebrata).

MOLLUSCA.

Limpet, Whelk, Snail (p. 297)	**Gasteropoda.**
Tooth Shells	**Scaphopoda.**
Mussel, Oyster, Razorshell (p. 311) ...	**Pelecypoda.**
Cuttlefishes	**Cephalopoda.**

ARTHROPODA.

Flies, Bees, Butterflies, Beetles, Cockroaches, Waterboatmen, etc.	**Insecta.**
Centipedes and Millipedes	**Myriopoda.**
Spiders, Mites, Ticks, Scorpions, Kingcrabs	**Arachnoidea.**
Crabs, Lobsters, Shrimps, Prawns, Woodlice, Barnacles, Acorn Shells, Water Fleas (p. 200)	**Crustacea.**

ECHINODERMATA.

Starfishes (p. 429)	**Asteroidea.**
Brittle Stars	**Ophiuroidea.**
Sea Urchins	**Echinoidea.**
Sea Cucumbers	**Holothuroidea.**
Sea Lilies (Feather Stars)	**Crinoidea.**

PODAXONIA.

Lamp Shells	**Brachiopoda.**
Sea Mats	**Polyzoa.**

ANNELIDA.

Fisherman's Worm, Sea Mouse, *Serpula* Earthworm (p. 320)	**Chaetopoda.**
Leeches	**Discophora.**

Arrow worms (*Sagitta*) and Gephyreans are placed here.

NON-SEGMENTED WORMS. (A Mixed Group.)

Thread Worms, Horse-hair Worms. "Paste Eels," "Vinegar Eels."
Ribbon Worms.
Rotifers.
Tapeworms, Flukes, Planarians.

COELENTERATA.

Hydra and Hydra-like Colonial Animals (Hydrozoa).
Jellyfishes.
Sea-anemones. All kinds of Corals.

PORIFERA.

Purse Sponge (Sycon).
Venus' Flowerbasket, Glass-rope Sponge.
Freshwater Sponge, Boring Sponge, Bread-crumb Sponge, Mermaids' Gloves.
Bath Sponge (p. 434).

PROTOZOA. Single-celled animals (mostly).

Amoeba, Globigerina, Euglena, Gregarina.
Paramoecium, Stylonychia, Vorticella.

OUTLINE CLASSIFICATION OF PLANTS.

For the benefit of the teacher who is only partially trained in the study of plant life, the following outline scheme of classification is provided. In the sphere of both plant and animal life the student commencing observational work is hampered and confused by the bewildering variety of structure he meets with, and until he has been able to see orderliness in the world upon which he has entered he lacks confidence in teaching and that perspective in his outlook without which the best and most effective teaching is lacking.

On the principle of commencing with the relatively familiar and passing to the less familiar we frame our scheme starting with the higher plants known as Phanerogams, passing in a systematic series to the lowest plant forms.

A. PHANEROGAMS.

Flowering plants, propagated by means of **seeds.**

ANGIOSPERMS. Ovules borne within closed carpels.

(*a*) **Dicotyledons.**

Flower characters indicated below.
Leaf venation usually netted.
Stem with open vascular bundles and growth in thickness of stem and root takes place through a cambium layer.
Seed with two cotyledons or seed leaves.

Examples:—

Willow,
Birch (p. 41),
Beech (p. 47),
Oak,
Elm (p. 41),
Nettle,
Dock,
Chickweed,
Poppy,
Wallflower (p. 12),
Rose,
Pea (p. 120),
Geranium
Holly (p. 377),
Mallow,
Violet (p. 18),
Willowherb,
Hemlock,
Mistletoe (p. 380),

With the segments of the perianth **free.**

Rhododendron (p. 34),	Flowers with **five** regularly alternating whorls, calyx 5, corolla (5), stamens 5 + 5, pistil (5)	With the petals **coherent.**
Forget-me-not, Deadnettle (p. 151), Potato, Speedwell (p. 148), Plantain (p. 164), Honeysuckle (p.247), Harebell (p. 239), Daisy (p. 134),	Inner whorl of stamens wanting, calyx 5, corolla (5), stamens 5, pistil (5) or (2)	

(*b*) **Monocotyledons.**

Examples :—

Grasses, Wheat, Barley, Oat, Cuckoopint, Rush, Tulip, Lily, Hyacinth, Snowdrop, Narcissus, Iris, Crocus, Orchid,	**Flowers** usually five-whorled consisting of three parts each. The two outer whorls usually resemble each other, forming the **perianth.** Perianth 3 + 3, stamens (androecium) 3 + 3, Pistil (gynoecium) (3). The **leaves** have parallel veins, are linear or ovoid lanceolate in form, usually sessile and sheathing, alternate. Adventitious roots replace the main root, vascular bundles are closed and without cambium.

GYMNOSPERMS.

Examples :—

Yew, Pine, Larch, Spruce, Juniper,	The ovules are borne upon open carpels, flowers are unisexual. Shrubs or trees.

B. CRYPTOGAMS

Non-flowering plants.

PTERIDOPHYTA (Vascular Cryptogams).

Ferns (p. 274), Horsetails, Clubmosses, *Selaginella*,	With vascular tissue for the conduction of nutritive substances. Producing spores.

Bryophyta.

Mosses,	Producing spores. With stems and leaves; no true roots. Vascular conducting tissue simple.
Liverworts,	Simpler in structure than the mosses.

Thallophyta.

Bacteria, Diatoms, Stoneworts (*Chara*, etc.), Green Algae, Brown Algae (*Fucus* p. 281, *Laminaria*), Red Algae (*Delesseria*), Moulds, Toadstools, etc. (p. 345), Lichens,	Not possessing stems, leaves, and roots. The plant body consists of one or more cells forming a thallus. There is both sexual and asexual reproduction.

GLOSSARY.

(Botanical.)

achene : a dry single-seeded non-splitting fruit.

actinomorphic : rayed in form, *i.e.* with radial symmetry.

adhesion : the union of unlike parts, *e.g.* of stamens and petals.

ala : wing ; **alate** : winged.

androecium : applied to the whole collection of stamens in a flower.

angiosperm : flowering plants whose seeds are developed in a closed cavity, the ovary.

annulus : a specialised band of cells upon the sporangium of ferns, whose walls are thickened upon their inner borders and which by the tension developed in them through loss of water bring about the rupture of the sporangium and subsequent scattering of the spores. Applied also to a ring of specialised cells upon the capsule of mosses.

anther : the portion of the stamen in which the pollen is formed.

antheridium : the organ producing male elements in the group to which ferns and mosses belong.

anthocyan : a type of pigment widely distributed amongst higher plants.

archegonium : the organ producing female elements in the group to which ferns and mosses belong.

aril or **arillus** : a growth upon a seed, commonly fleshy or hairy, *e.g.* the fleshy cup upon the seed of the Yew, and the tuft of hairs upon the seeds of Willow-herb, Willow, and Poplar.

axil : the angle between the base of a leaf (upper side) and the stem or branch from which it arises.

bark : the tissue upon the outside of the phellogen (cork-producing layer) in plants. It is dead, being deprived of food supplies.

bast : the tissue in the fibro-vascular bundles which serves to conduct elaborated food materials. Also called phloem.

berry : a fruit in which the parts around the seeds within the skin become fleshy or pulpy.

bract : a leaf in the axil of which a flower or flowering branch arises.

bud : an undeveloped shoot.

bulb : a reduced underground shoot whose leaves are thick and fleshy with stored food.

bulbil : a small bulb formed in the axil of a foliage leaf.

calyx : the outermost whorl of a typical flower, viz. the sepals.

cambium : the layer between the wood and bast in which growth resulting in increase in thickness of stems and roots takes place.

capitulum: an inflorescence in which the flowers are sessile upon a shortened principal axis, *e.g.* dandelion.

capsule : a dry fruit opening when ripe to allow of the escape of seeds.

carina: a keel. The anterior petals in a papilionaceous flower.

carpel : the part of the flower in which the ovules develop (*see* **ovary**, also **gynoecium**).

catkin : a close set more or less elongated inflorescence (spike) in which the flowers are unisexual.

chlorophyll : the green colouring matter in plants.

chloroplast : the small protoplasmic bodies in plants containing chlorophyll.

chromoplast: small protoplasmic bodies containing pigment other than chlorophyll.

cleistogamous: applied to flowers which do not open, in which self-pollination occurs (*kleistos*, closed ; *gamos*, marriage).

cohesion : the union of similar parts, *e.g.* of petals together.

conidia : non-sexual reproductive bodies occurring in certain moulds, etc.

coniferae : cone-bearing trees.

corm : a reduced swollen underground stem with food reserves, buds, scale-leaves, and roots (Fig. 154).

corolla : the inner whorl of floral parts, next to the calyx—usually coloured ; the petals (*see* **perianth**).

corona : a ring-like growth arising upon the inner side of the corolla, *e.g.* in Daffodil and Narcissus.

cortex : the layer of tissue in a stem immediately below the epidermis.

corymb : a flat-topped inflorescence, in which the individual flower-stalks arise at different levels (Fig. 53).

cotyledons : the leaves of the embryo within the seed (Fig. 24).

cuneate : wedge-shaped.

cupule : a cluster of bracts (involucre) united to form a kind of cup investing certain fruits, *e.g.* acorn, beech, hazel.

endocarp : the innermost layer of the pericarp, *e.g.* the "stone" in a cherry.

endosperm : a nutritive tissue occurring in many seeds and absorbed by the young plant at germination.

epicarp : the outermost layer of the pericarp or wall of the fruit, *e.g.* the skin of a cherry.

epidermis : the outermost skin layer.

epigynous : a type of flower in which the head of the flower-stalk grows around and above the ovary, uniting with it so that the remaining parts of the flower arise above that organ.

epipetalous : arising upon the surface of the petals, *e.g.* stamens in primrose.

fibro-vascular bundles : the system of vessels which conduct nutrient materials in all higher plants, including ferns, etc.

filament : the slender portion of the stamen which bears the anther.

floral diagram : a diagram to illustrate the relations of the several parts of a flower to each other.

floral formula : a formula to illustrate the numbers of the parts of a flower and their relations, *e.g.* K (5), C 5, A (5 + 5), $\underline{G}$, which reads : calyx of 5 united sepals, corolla of 5 free petals, two sets of stamens, 5 each, all united, and one superior carpel—flower of Broom.

follicle : a dry fruit consisting of a single carpel, which opens when ripe along the ventral or seed-bearing margin.

frond : a leaf of a fern.

funicle : the stalk of the ovule or seed.

gamopetalous : applied to the corolla when there is union (cohesion) of its constituent parts.

gamosepalous : applied to the calyx when the sepals are united, either partially or completely.

germination : the commencement of growth of the embryo within a seed.

glumes : the scales or bracts enclosing a grass spikelet.

gymnosperm : a plant in which the ovules develop in an exposed position (*e.g.* Coniferae), in contrast to angiosperms, where the ovules are contained within closed carpels.

gynoecium : the whole collection of carpels in a flower = the pistil.

herbaceous: plants or those parts of them which die down after each year's growth is completed.

heterostyly : applied to flowers which exhibit styles of more than one length, *e.g.* primrose.

hilum : the scar upon a seed marking the place where it broke away from its stalk.

hypodermis : the part of the cortex adjacent to the epidermis when it is specially strengthened.

hypogynous : the type of flower in which the whorls of sepals, petals, etc., occur in regular succession upon the receptacle, the pistil being at the apex.

indusium : the membranous covering of the sporangia in ferns.

inferior : applied to the position of the calyx in flowers of the hypogynous and perigynous types ; also to the ovary in epigynous types.

inflorescence : the whole region of a plant upon which flowers are borne.

involucre : a close set series of bracts around an inflorescence, *e.g.* on dandelion.

lamina : the thin flattened portion of a leaf ; the blade.

lanceolate : narrow and pointed ; lance-shaped.

latex : a fluid substance contained in a specialised tissue in certain plants. It is often milky in appearance, *e.g.* in dandelion. It may be excreted matter or have a nutritive function. Opium and caoutchouc are examples of latex.

legume : *see* **pod.**

lenticel : a place in the bark of a tree where the cork cells are loosely packed, permitting interchange of gases.

lipochrome : a group of pigments occurring in organisms. They vary from red to yellow.

mesocarp : the middle layer of the pericarp. It is a succulent layer in the cherry, fibrous in the coco-nut.

mesophyll : the cellular tissue occupying the inner space in a leaf. In a typical leaf it consists of the palisade layer and the spongy tissue.

micropyle : a minute opening in the coat of the seed. It is the same opening through which in the first instance the fertilising substance from the pollen usually enters the ovule.

monocotyledon : having only one seed leaf (sometimes a second, in a vestigial condition, is present).

mosaic : applied to the disposition of the leaves upon a plant whereby overshadowing is prevented.

mycelium : the substance of a fungus distinct from reproductive parts, consisting of a mass of interlacing branching threads (*hyphae*).

nectary : a part of a plant producing sweet stuff for the attraction of visitors.

node : the place upon a stem or branch where the leaves arise.

nut : a dry non-splitting fruit having woody walls, and containing a single seed.

obovate : a reversed ovate form ; broadest at free end, *e.g.* leaves of Alder.

orbicular : rounded, approaching the circular in outline.

ovary : the hollow part of the pistil in which the ovules develop.

ovate : approaching the shape of an egg in outline. Applied to leaves which are rounded, longer than broad, and broadest towards the base.

ovule : the developing seed, prior to fertilisation.

palea : the scale or bract adjacent to the flower in a grass (the glumes occur outside the palea).

palisade layer : the close-set layer of cells, longer than broad, lying below the upper epidermis of a leaf.

palmate : shaped like the palm, with spreading lobes.

panicle : a type of inflorescence in which the main axis bears lateral racemes ; seen in the oat.

pappus : the circlet of soft hairs seen on the fruits of many compositae, *e.g.* Dandelion. It is the calyx.

pedicel : the stalk of a single flower.

pendulous : drooping, *e.g.* many catkins.

penninerved : a type of leaf having the veins arranged like the barbs in a feather.

perennial: persisting for three or more years.

perianth: the outer parts of a flower, a term generally used when calyx and corolla cannot be separately distinguished.

pericarp: the wall of the fruit.

perigynous: a type of flower in which the receptacle is flat or cup-like, the sepals, petals, and stamens arise around its edge, and the pistil in the centre.

petals: the parts of the corolla, usually showily coloured.

petiole: leaf-stalk.

phellogen: cork-forming.

pileus: the "head" of a mushroom or toadstool.

pinnae: the lobes into which fern fronds are usually divided. They may be simple or themselves divided into pinnules.

pinnate: a type of leaf in which the lobes or leaflets are arranged in serial pairs.

pinnatifid: a type of leaf having slight lobes cleft in series like the parts of a feather. The notches between the lobes extend to about halfway to the midrib.

pinnule: the lobes into which the pinnae of fern fronds may be cut.

pistil: see **gynoecium.**

pith: the central part of the ground tissue in stems and branches. It is also applied to similar tissue in certain roots.

placenta: the part of the ovary on which the ovules develop; also the part from which the sporangia in ferns develop.

placentation: the arrangement of the placentas in an ovary, *e.g.* parietal, when these are upon the walls.

plumule: the young shoot which emerges from the seed at germination.

pod: a dry fruit, consisting of a single carpel, which opens along both ventral (seed-bearing) and dorsal margins.

pollen: the fertilising substance of flowering plants.

pollination: the application of the pollen grains to the stigma.

pome: a succulent fruit whose fleshy part is formed from the receptacle, *e.g.* apple.

prickles: sharp spiny structures arising from the epidermis of plants. They do not contain wood. Contrast spines.

procumbent: applied to stems lying along the ground but not rooting.

protandry: male elements mature before female.

prothallus: the body which bears the sexual organs in the fern and allied plants; the sexual generation.

protogyny: female elements maturing before male.

raceme: an elongate inflorescence in which the flowers are borne on simple stalks.

rachis: the main axis (midrib) of a compound leaf or of an inflorescence.

radicle: the root of the embryo plant which emerges from the seed on germination.

receptacle: the top of the flower stalk from which the parts of the flower arise.

rhizoid: the structures which perform the work of roots in mosses and in the prothallus of ferns. They are not true roots.

rhizome: an underground stem or rootstock usually with food store, giving rise to aerial shoots and leaves, and to adventitious roots.

runner: a creeping shoot growing along the surface and rooting and giving rise to buds in the axils of scale leaves at the nodes. A stolon.

saccate: baggy.

samara: a dry, non-splitting winged fruit, *e.g.* as in Ash, Elm, Birch, etc.

sepals: the parts of the outermost whorl of the flower, *i.e.* the calyx.

septum: a partition.

serrate: toothed like a saw.

sessile: without stalk.

shrub: a woody plant. It differs from a tree in retaining its lateral shoots, so that it has branches arising from near the ground. In a tree these lower branches are lost.

silicula: a short and broad fruit of the siliqua type, *e.g.* fruit of Shepherd's purse.

siliqua: a slender pod-like fruit, whose two valves split off leaving the seeds attached to the margins of a middle membranous partition, *e.g.* fruit of Wallflower.

sorus: a cluster of spore-containing capsules (sporangia) occurring on the fronds of ferns.

spadix: an elongated inflorescence with sessile flowers in which the axis is thick and fleshy, *e.g. Arum.*

spathe: usually a leaf enveloping a type of inflorescence known as a spadix; a particular type of bract. The term is also applied to the membranous bract of the Narcissus flower.

spike: an elongated inflorescence with sessile flowers. *e.g.* Plantain.

spine: a sharp woody structure; a modified branch, leaf, or leaf stalk.

sporangium: the spore-containing capsules on the fronds of ferns.

spore: a unicellular propagative body.

stamen: the essential male structure in a flower. A stamen consists of a stalk (filament) which bears an anther (pollen-producing part). The filament is united to the anther by the connective.

staminode: an infertile stamen, not producing pollen, *e.g.* in figwort.

stigma: the part at the terminal portion of the style which is modified for the reception of the pollen grains.

stipules: leaf-like appendages at the base of the leaf stalk, characteristic of certain plants.

stomata: openings upon the epidermis of leaves and young stems for gaseous interchange and transpiration of moisture.

style: the upper part of the pistil, usually elongated, which bears the stigma.

sucker: an underground runner which develops aerial shoots. Applied also to the parasitic roots of certain plants.

superior: applied to the position of the ovary in hypogynous and perigynous flowers.

syncarpous: a pistil of more than one carpel, whose parts are coherent.

tendril: a part of a plant adapted for climbing. It may be a leaf, part of a leaf, or stem.

testa: the coat of the seed.

tetrad: a group of four.

thallus: a type of plant in which stem, leaves, and root are not differentiated.

theca: the capsule in which the spores of a moss are developed.

transpiration: the giving off (as vapour) by leaves of water absorbed by the roots.

tuber: a portion of an underground stem or of an adventitious root thickened with food store.

umbel: a flat-topped inflorescence with stalked flowers arising at the same level, laterally from a reduced main axis.

valvate: an arrangement of the outer parts of the flower bud where the edges meet but do not overlap.

venation: the arrangement of the veins in a leaf.

versatile: a mode of attachment of anther to filament in which the former has free movement and swings readily, *e.g.* anthers of grasses.

whorl: a circle of similar structures, *e.g.* leaves or floral parts, arising at the same level.

xanthophyll. a yellow vegetable pigment occurring in association with chlorophyll.

zygomorphic: divisible in one plane only into two similar parts, *i.e.* showing bilateral symmetry.

(Zoological and General.)

adductor: a muscle for closing the shell in a Bivalve.

allantois: one of the membranes attached to the unborn or unhatched young in mammals, birds, and reptiles. It subserves nutrition.

alternation of generations: the alternate occurrence of two generations, sexual and asexual, in the course of a single life-history, *e.g.* Fern or Jelly-fish.

amnion: a protecting membrane around the unborn or unhatched young in mammals, birds, and reptiles.

Annelida: a class of ringed or segmented worms.

antenna: the jointed sensory filaments upon the head of many animals of the Arthropod group.

Arthropoda: the group of Invertebrate animals with *jointed feet* (insects, spiders, etc.).

assimilation: the process in living bodies in which food materials are transformed into living substance.

autotomy: self-mutilation.

barbule: a sensory filament upon the head of certain fishes.

calcar: a small nodule occurring on the inner side of the hind foot of frogs and toads.

cell: the unit of living matter, plant or animal. It consists of at least a nucleus and surrounding plasma.

Cetacea: the Order of Mammals to which the whales belong.

Chaetopoda: bristle-footed. A group of Annelids.

chalaza: the thickened cords of albumen to be seen in a fowl's egg.

chitin: the organic substance which forms the cuticle of the body in Arthropods.

chrysalis: the stage between larva and adult in lepidopterous insects in which metamorphosis takes place.

cocoon: the case of silky hairs which encloses the pupa of many insects. Also applied to the cases in which the eggs of spiders and other invertebrates are enclosed.

Coelenterata: the name applied to the group of stinging animals, *e.g.* jelly-fishes and sea-anemones; so-called because the only cavity or space within the body is the gut (Gr. *koilos*, hollow; *enteron*, the gut).

Coleoptera: the Order of Insects (Beetles) whose fore wings are modified to form a sheath for the second pair as well as the rest of the body behind.

commensals: literally, sharers of the same table. Animals of different kinds forming a mutually beneficial partnership, *e.g.* hermit crab and sea-anemone.

coracoid: the bone forming the ventral part of the shoulder girdle in vertebrates; so-called because in man it has a fancied resemblance to the bill of a crow (Gr. *korax*, a crow; *eidos*, form).

Crustacea: a class of Arthropod animals, almost entirely aquatic, whose cuticles contain carbonate of lime and which have thus a hard shell-like exterior.

cuticle: a layer secreted upon the outside of epidermal cells.

Diptera: the true flies. They have one pair of wings only.

Discophora: bearing suckers. The group of leeches.

drone: the males in a bee colony.

Echinodermata: the sea-urchins, starfishes, etc. (Gr. *echinos*, a hedgehog; *derma*, skin).

ecology: the branch of study which considers the relations of organisms and their environment.

Elasmobranch: the sharks and rays.

elytron: the modified fore pair of wings in beetles.

embryo: the young plant within the seed or animal prior to the stage at which it feeds itself.

fertilisation: the union of male and female elements which results in the development of a living organism.

Ganoid: the group of fishes to which the sturgeon belongs. Ganoid refers to the brilliant appearance of the scales of certain members of the group.

gland: an organ which produces (secretes) a substance or substances of use to an animal or plant. Certain glands are excretory.

grub: a type of insect larva, exemplified by beetles and bees. A true grub has a distinct head and three pairs of jointed legs upon a worm-like segmented body.

haemoglobin: the red colouring matter in blood.

halteres: the rod-like bodies in flies taking the place of the second pair of wings. They are also known as balancers.

Hemiptera: an Order of Insects, the bugs, plant lice, etc. In typical members of the group (Heteroptera) the fore wings are partially hardened, forming covers for the hind pair.

humerus: the bone of the upper arm.

Hymenoptera: membrane-winged. The Order of Insects to which ants, bees, wasps, sawflies, ichneumon flies, etc., belong.

imago: an adult. Generally applied to the mature insect after metamorphosis.

infusoria: a group of ciliated Protozoa, so termed because they occur in hay and other infusions.

Insectivora: an Order of Mammals: see Text.

instinct: a type of behaviour more or less complex, which is carried out without training or previous experience.

invertebrate: without backbone. Invertebrates have no bones of any kind.

larva: the active young of an animal when it is in structure and habits unlike the parent, *e.g.* caterpillars or tadpoles.

lateral line: a line which may be seen on the side of a bony fish's body. It is sensory in function.

Lepidoptera: scaly wings. The Order to which moths and butterflies belong.

ligament: in bivalves, applied to the band of conchin which joins one valve to another. It is part of the hinge apparatus.

lymph: that part of the blood plasma which conveys nourishment to the tissues. It is the intermediary between the tissues and the blood.

madrepore: the perforated plate leading into the water vascular system in the starfishes, etc.

maggot: a type of larva distinctive of true flies (Diptera). It is without legs, and the head is either very imperfect or absent.

metamorphosis: the change of form undergone by some animals before reaching the adult state.

metazoa: those animals whose bodies are multicellular and in which division of labour is apparent. Literally, all animals except the Protozoa.

mimicry: a resemblance between harmless and harmful species of animals, owing to which the former are believed to derive protection; see p. 289.

mollusca: soft-bodied invertebrate animals, mostly with limy shells, *e.g.* Snail, Oyster.

mosquito: "Little fly." A widely used term for blood-sucking flies of the family Culicidae, of which the gnats are familiar examples.

notochord: a supporting axial rod of cartilaginous texture which appears in embryonic life below the spinal cord of vertebrates. In all above fishes it is replaced by the backbone.

Oligochaeta: having few bristles. A subdivision of the bristle-footed Annelids.

Orthoptera: an Order of Insects in which the nervures upon the wings run in straight lines, *e.g.* Cockroach, Grasshopper.

ovipositor: an organ at the hinder end of the body in the females of many insects; of use in depositing the eggs, and sometimes specialised for pricking plant or animal skins so that the eggs may be laid in the interior. The sting of a wasp or bee is a modified ovipositor.

pallial: relating to the pallium or mantle.

pectoral: relating to the breast, *e.g.* pectoral muscle; pectoral fin.

pedicellariae: the clipping blades or pincers upon the skin of a starfish or sea-urchin.

pelagic: applied to animals and plants whose habitat is the open sea, as distinct from the littoral and deep sea areas.

pelvic: relating to the hip girdle, *e.g.* pelvic fins of fishes.

phenology: the study of the periodic appearance of plants and animals in relation to the seasons.

phylum: a stock or race. Applied to the larger groups of the animal kingdom, *e.g.* Mammalia or Aves are phyla.

porifera: having pores. The Sponges.

proboscis: a general term applied to the mouth parts collectively of insects.

prolegs: the temporary locomotor structures occurring upon the hind body (abdomen) of the larva of some insects.

protista: applied to those organisms which appear to be on the borderland between plants and animals.

protozoa: the simplest animals.

pupa: the stage between larva and imago in which metamorphosis in insects takes place. It is of more general significance than the term chrysalis.

radius: one of the bones of the lower arm.

radula: the chitinoid toothed ribbon in the mouths of certain molluscs. It is absent in bivalves.

Rodentia: an Order of Mammals, with long curved persistently growing incisor teeth.

scapula: the shoulder blade. The backwardly directed portion of the shoulder girdle.

spiracles: the openings into the tracheal or breathing tubes of insects, also known as stigmata.

stigmata : *see* **spiracles**.

tadpole : toad-poll (a toad with a big poll). The larva of frog or toad.

tarsus : the ankle region in vertebrates. Also the terminal joints in the legs of insects.

Teleostei : completely bony. A group of fishes in which the skeleton is completely ossified, *e.g.* Cod.

thorax : the chest region. In insects the middle division of the body consisting of three fused segments.

Turbellaria : a group of non-parasitic flatworms, *e.g.* the Planarians, which occur upon pond-weed in streams or stagnant water.

ulna : the bone of the lower arm which can be felt at the elbow.

umbilicus : a term applied to the pillar-opening in univalve shells ; also to the openings at the base and top of the quill of a feather.

Ungulata : an Order of Mammals whose toes are ensheathed in hoofs.

vertebrate : the division of the animal kingdom which is characterised by the possession of a backbone.

wireworm : a kind of grub. The young form of Click beetles, so called because they are tough-skinned or wiry.

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